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Journal

OF THE MICHIGAN SCHOOLMASTERS' CLUB AT THE THIRTY-SEVENTH MEETING HELD IN ANN ARBOR MARCH 27, 28, AND 29, 1902.

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Michigan Schoolmasters' Club

PROCEEDINGS OF THE THIRTY-SEVENTH MEETING, HELD AT ANN ARBOR, MARCH 27, 28, AND 29, 1902

PAPERS

EDITED BY THE CHAIRMEN OF THE VARIOUS SECTIONS

GENERAL MEETING

Preparation for Life, and Preparation for College.

PROFESSOR GEORGE REBEC, UNIVERSITY OF MICHIGAN

One question usually involves many questions. When we ask, "Does the same education prepare best both for college and for life," our whole answer is contained in what we understand by "preparation for life," and by "preparation for college." To these latter questions, therefore, we must address ourselves.

I shall say my worst first. It is my opinion that the best preparation alike for college and for life is culture. I hurry to add, however, that though I mean what I say, the extravagance is rather in the term than in the thing really intended. Permit me to enlarge.

To begin with, by culture I do not mean simply the fragile fruits of a course of so-called select and high-toned studies. Culture embraces the whole substantial business of self-realization—self-fulfillment on every side, spiritual and physical,—and this not merely in a private, individual way, but of the man as a social being. It is true that the practical educator, while laboring with his whole strength to instill in the youth the love of his social self and to call forth the richest growth possible of that self, yet will always endeavor not to run counter to nature in the man. He will have regard to his primitive spontaneous ego, its quality, interests, and aptitudes, and will so try to direct him as to utilize for his social being and not merely thwart, the natural man in him. A too steady crucifixion of the flesh never leads to the highest human product, and in the average case is more than likely merely to fag and kill the life and spirit out of a man. The watchword of

modern pedagogy is, find an outlet for nature. And yet, when the situation arises wherein conflict between the private and universal self is inescapable, the private must be taught to yield. The man must be trained to the habit and strength to compel it to yield; he should be moulded to feel the joy of another and higher fulfillment of self in the very defeat of self. Self-sacrifice, duty, hardship, routine are realities in life; they are with us not only in certain grand crises of existence, but in a thousand and one trifles every day and almost every hour. I do not, under common sense, see of what else the moral conflict and hard moral lift consist. And yet, from the way in which so much of our nineteenth century pedagogy has interpreted the gospel of the "Return to Nature"—of freedom, spontaneity, and interest in education — these would seem to be things to be obviated. While as ready as any man to be dubbed an apostle of culture, I part company from the mere preachers of the pleasant. I believe education in large part to be *through* and even *for* self-sacrifice, hardship, obedience, discipline, mechanism, routine.

The just-named conditions of unfreedom, we might observe, come into the schoolroom in two ways. In part they are incidental to the carrying out of the educational program. More or less of mechanical division into grades and classes, courses of study, abstractly separate subjects, arbitrary times and seasons, more or less changing of teachers and fellow-pupils and schools, more or less in the way of interruptions and the thousand and one things we call accidents, there must always remain with us. In fact, the residue of it all will always be sufficient fully to justify the continuance of earnest efforts to overcome it. So far as it cannot be absolutely eliminated, the intelligent teacher will endeavor, to the extent that he can, to reconcile it with his purposes — he will transform his hindrances into opportunities, and make of precision, regularity, clear-cut distinction, change, intermission, etc., downright stimulants of interest and enthusiasm. For the rest, if some of these freedom-marring elements still remain over, the wise teacher will not be too distressed. He will not become a mediaeval worshipper of hardness; he will not countenance it needlessly, much less feel obliged to go far out of his way to find it; but seeing it inevitably in his path, will he not recognize that it is the very stuff of which a great part of real life is made? Real affairs do not wait upon our moods and pleasure: those of us who try to go on the æsthetic expectation that they will, know how little we do do. The dead lift is a living fact.

In part the factors of mechanics, routine, and pain come into the school because they are innately involved in education itself. You can't completely get rid of preliminary and instrumental studies, which are mere cold means to an end other than themselves. The boy who will not learn grammar, cannot know Latin. Of course, here again the educator must labor on to get rid of the old-time love of the dry and disagreeable. He may count upon it, that *serious* learning, like serious practical living and social adjustment, involves enough of the hard and unpleasant and remote without our making very special search after it. He will therefore strive, as far as in good sense he dare, outright to get rid of it; or where he cannot directly do this, he will try to transform it, by awakening an interest in it for itself through finding for it a meaning in the student's life in general; or, further still, he may frankly concede that a given study is only a means, but will try to help his pupil vividly appreciate that it is and how it is a means, and as such vital; or — last resource of all — he may to some extent legiti-

mately attempt even to arouse an adventitious interest for it. But beyond this, he will remember that he has to do here only with an illustration of a phase of the real nature of things themselves, a phase which, if he is to train for the actual conditions and activities of the world and not for a mere kindergarten paradise of pleasant illusion, cannot be blinked and sentimentally dodged, but needs to be reckoned with as a positive and radical factor in effective education itself.

Evidently, we intend that culture shall include rigor and regard for the actual serious requirements of existence. But does not preparation for life involve something more than these generalities, however excellent they may be? What shall we say once more to the never-silenced grumble of the materialistic public that the youth, whether in the secondary or any other school, ought to be learning to make a living and to do actual ordinary things? Have we not here a demand fatally hostile to the liberal sort of training we have just been describing, and may not our liberal culture itself in a way be inimical to the prosaic practicality that fits a man for the world? Though this anxiety about a living should command the respect due it as born of the immemorial grim experience of the people, nevertheless our answer too must continue to be the old immemorial one, "Man shall not live by bread alone." Especially in these days of the weakened authority of the Church must our schools be the shrines of idealism: it will be a dreary day for our civilization when we accept the motto that the whole end of life is to get a livelihood for ourselves and ours. China even has not unqualifiedly assented to that maxim. Moreover, it is not simply an ideal, but the unadorned truth that the man is more than the carpenter and the man's relations more than the carpenter's; so that the schoolmasters and mistresses who almost everywhere, at least in this land, have been struggling to keep our popular schools from sinking into mere institutes for the three R's and bookkeeping, have been waging a fight not only for idealism but for fact. And yet is there not some justice in the brusque retort of the people's elders, that for all that the man must live? Bread *is* the staff of life; and since it is the doom of the mass of men to earn their bread, why not provide for their education in the bread-studies before giving room to the studies that furnish only the desserts to life's banquet? Of course, our answer is, that the most effective way of earning your bread is to equip yourself to earn much more than your mere bread. An awakened mind, a disciplined will, ready sensibilities, and a trained eye and hand are indefinitely more to a boy or girl than any amount of mere knowledge of technical bookkeeping or blacksmithing, or cooking and sewing. Still, is this the sum of the whole matter? Is it the fact that simple intelligence in general necessarily makes the good bookkeeper, or that ability to throw the ball or put the shot trains the blacksmith's arm, or skill in picking out the shades on colored cards develops the milliner's peculiar taste? Quite obviously not. Accordingly, if the end of all education is wholeness of life, and the foundation of life is a living, why should not our schools, on behalf of the vast majority to whom the living can come only through their own making of it, provide the specific training that alone will make the making of the living possible? To be sure, it is a millennial notion to expect the schools to be able to give minute instruction in all the arts and trades; however, callings, as Professor Dewey has lately been so well pointing out, fall into typical groups. Why not, therefore, do at any rate as much as we can, by bunching our pupils together under one or the other

of these vocation-groups, according to their aptitudes and carefully observed tendencies, and instructing each as far on as possible along his proper line? The objection that of course recurs is the same one,— that in spite of all, the man is more than his trade, that there is a wider knowledge and a wider human nature, and there are wider human relationships than those of mere craft and business, and that these must not be subordinated to any mere scheme of giving the man a trade: in the competition of studies in the common school, the so-called practical must yield to the more broadly human. I agree completely with this contention, and so far enroll myself with the idealists and professors against what is usually supposed to be the position of the hard-headed practical men and business-men. Indeed, it asks no profounder reason to bring one to agree here, than to point out that any defect of mere detail of technical knowledge is more easily made up out in the ordinary world, than is a deficiency of that inward education that makes for largeness of outlook and being. Does this alternative, though, of choosing between the mercenary and the culture-studies press so hard as we are commonly disposed to think it does? I cannot help feeling but that, with the best intentions, our teachers — more especially in the high schools — have been quite wrong-headed in this connection. On the one hand, perceiving instinctively the soul-killing drift of the gospel of naked utility, they have been impelled into a blind, wholesale reaction; while on the other hand, like all the rest of us, they have been traditionally given to separating the world of studies, as Professor Dewey puts it, into two regions, — the high-toned and the vulgar; and the distinction has largely been based on whether or not the particular study had anything to do with ordinary life and affairs. Remoteness and aloofness have been supposed somehow to confer aristocracy upon studies as upon men. Now I am not ready to assert that all subjects are indifferently of equal culture-value; but I do hold that the differences have been greatly exaggerated. What is there about bookkeeping and banking or the use of machinist's tools that should make it impossible to make them play into general intellectual interest, general purpose, and even general human sentiment? Let us, besides, remember that man — and especially the child-man — is an imitative creature, and one living much in expectation, and that what he sees to imitate and what he expects to be and do, deeply stirs his interest — that motive power without whose eager response every endeavor to bring a man to selfhood is vain. But now what he sees about him to imitate, and what by the overpowering preponderance of obvious example he expects himself to be at, is precisely the common useful crafts and occupations. Our small boy, unless he is a hopeless little prig, does not play or look forward to being missionary or silver-tongued orator, but fireman and farmer. Everybody knows too the general success manual training has had in the schools with the children. The commonplace, practical subjects, it would appear, have even a certain advantage in the purely cultural aspect. I am not sure also but that the thought that the subjects are to help him earn a living will not have a certain leverage of arousing an interest in the student — an interest capable of being measurably exploited in a general cultural sense. Clearly, then, I can see no reason for not yielding to the practical fathers and mothers a large degree of what they want, — the introduction of materially useful branches to a prominent place in the curriculum of all our preparatory schools higher or lower.

Only here come in the colleges with their demand. It need not trouble us just now that our colleges have ceased to be simple in their aims and requirements, having become a sort of hodge-podge of a maturer continuation of the same culture course pursued in the high schools, and a lot of preliminary or inchoate professional studies of the true university, that is, graduate and professional school type: for our purposes, their various distinctive demands on the more elementary schools are reducible to one,—the demand for special scholastic knowledge. Now surely the preparation of men for college—which itself is but the preparation of men for forms of leadership and activity in the community without which the community is largely blind and its very everyday work largely meaningless—is a legitimate and indispensable part of the business of the secondary school. But how are we going to get this function done, if we insist on introducing into the high school all manner of studies preparatory for the world? Shall we not end in utter bewilderment with every vestige of unity and simplicity of purpose vanished from our program? No doubt, the problem is a very real one, and not to be settled by any man off-hand. And no doubt that in its settlement numerous balancings and compromises must be made. In arriving at any solutions, however, two considerations ought to be weighed. First, have we not been traveling with rather exaggerated ideas of the amount of technical, special accumulation our boys and girls must be asked to bring with them to college? I may be disclosing myself as hopelessly unscholarly, but I frankly avow that my experience as a teacher has been that, even for advanced special work, the young man or woman who, though his technical preparation be quite deficient, yet is one who has come to himself, whose mind has been found out and his free interest stirred to movement, is indefinitely preferable to the person who has been thoroughly through the formal grind, but never has come into the intellectual possession of himself. I believe, too, that this is the regular experience of teachers. But we have seen that self-development is attainable through many other than the narrowly scholastic means. Why not, then, bravely act up to our convictions and the facts in this matter of college-entrance requirements? Still, the case is not all one way here either. The boy who has not ground his Latin grammar and prose cannot expect profitably to read Horace or Lucretius, just as he cannot work his analytical geometry if he knows nothing about common algebra. The course that looks to life and that which prepares for college are not identical. Each unavoidably has its special bias; and so we are obliged to face a second consideration, namely, whether, like the Europeans, we shall not be obliged to have two distinct courses in our secondary-school system. Our American democracy, with the constant shifting of social classes and the suddenness with which, almost in an hour, the fortunes and prospects of a child in this country may alter, of course precludes of our ever drawing any such invidious line of demarcation as exists in Germany between the folkschool and the gymnasium. There must be fairly free intercommunication, a reasonably easy transition from the popular to the college-preparing course, and *vice versa*. As we have been saying, a great share of the so-called practical studies should be accepted in a liberal spirit as meeting college requirements; while everybody but a rampant champion of the three-months-in-a-business-college-and-then-into-business idea will concede that a very large portion of the more learned material has training-power of just the kind that even the plain people want. After this, what cleft remains between the college-

preparing courses and the courses preparatory more directly for life, need, perhaps, not to be so hopelessly wider than that between the boy's studies and girl's studies which nevertheless manage to subsist side by side in the same school.

However, suppose that after all is said and done, there persists a remainder of conflict between the popular and the scholastic studies, between the interests of the many who are looking towards the world and the relatively few whose eye is turned in the direction of college? I am more loath to commit myself to an answer than from my way of putting the alternative might seem. I hardly know which to prefer, or more accurately, which to esteem less, a democracy which slights its provisions for the secure prosperity of the higher science, art, and philosophy, or an aristocracy of superior culture which pursues its own concerns in abstract detachment from the well-being of the mass. Nevertheless, if we are to hold to our faith in our democratic gospel that the provision for the great majority at even a lower level is in the long-run better for society than the provision at a high level for the minority, we must, I suppose, decide that the sacrifice must be in the direction of the interest of the smaller number. In the ordinary American high school, Greek and even Latin must be prepared to take a back seat as against United States history and hygiene; and it behooves the professors of these and kindred subjects obviously for the benefit of the select college-going remnant, to ask themselves whether even now the time has not arrived for, say, such a concession to democratic prejudice as providing for beginning-classes within the college course itself, ideally or even pedagogically unsatisfactory as this, from every other point of view, may be.

A great deal of the tendency still survives among us to identify outright the scholastic, technically learned studies with the culture studies. This tendency partly springs from the natural error of confusing that which is an occupation of the few select, with what is itself select; but more particularly does it arise from tradition. First of all, it is a remnant of medievalism among us. In the Middle Ages, culture — if we may use the word in the connection — implied, not the modern pursuit of self-realization, but the literal gospel of self-renunciation. Even the moderate maxims of the time call, in all things, for humility and obedience to authority. The striving everywhere is to exhibit the spirit submissively receptive, disciplined, mortified; and these things are what constitutes mundane culture — if such a thing may be said to exist at all for an era to which the soul's proper being lies only in a blessed vision of the Beyond. For such an age, clearly, there can, in the training of the mind, be no harm but only virtue in reducing study to mere vigils of memory and painful persistence backed by literal physical fast and flagellation; just as for it the baldest, most formal grammar, rhetoric, logic, or arithmetic are genuine culture-studies; because for it the relation of studies to interest and the free natural life of the spirit is a matter only of negative concern. For such an age, clearly, culture can be only an external thing. When the Renaissance appeared, it is true it changed men's mood and reinstated the ideal of self-development; so that no longer could culture be submerged in the sapless learning that to this day is called scholastic. Nevertheless the new ideal of culture was obliged to be largely reminiscent — its best stimulus and suggestions were to be found back in ancient Greece and Rome. Therefore bare learning, though it ceased to have a cultural virtue in itself, became emphatically the

key to culture; and because it was the key to culture, men, by a natural piece of ill-logic, encouraged by a historic reaction towards mediaevalism which we cannot here enter upon, identified it with the substance of culture; and they continue numerously still to do so. Both the mediaeval and the later reactionary exaggerated conceptions of the worth of formal learning still largely prevail in our schools; and yet the simple fact is, that those studies whose obvious first distinctive mark in the high school is that they are technical preparation to special advanced work in the college, as regards their cultural value resemble more closely than any other branches those very practical ones against which, in the name of culture, they so often wage war. Culture, whatever else it includes, presupposes ideas, and sensibility to ideas, outlook, perceptive insight, and the living spirit; but wherein (to be moderate) does the first year of Latin, or Greek, or French, or a good deal of mathematics as taught, further all this markedly better than say so much household-economy or shopwork? I do not assert that scholastic studies — the most undisguised of them — have no cultural worth; nor that this worth cannot be increased; nor even that any irreducible remnant of dead weight about them is an unmitigated evil; but only that their real justification in the secondary curriculum remains their instrumental character, while their cultural quality for the most part is subordinate — in some respects inferior to that of the despised bread-and-butter subjects, which possess the interest of direct utility and relation to life. If this fact were better realized, it might spare us, for instance, such heaven-crying spectacles as a principal trying to induce a lad who in all human likelihood will never see the inside of a college, to take the high school two-years course in Greek, "because of the superior culture there's in it"!

All that we have so far said, throws light on what are the rights and proper place of those higher professional studies that nowadays are crowding their way down not only into the college but the high school courses. The attitude of educators towards these higher practical studies has been very much the same as towards the humbler practical ones. Teachers have been prone to feel as Aristotle did, when he forbade the young citizens of his ideal commonwealth not only to perform music professionally, but even to acquire skill up to the professional point. Professionalism seemed, to Aristotle, to introduce an illiberal element into education, and to distort the man from the pursuit of an unbiased, symmetrical self-development. Aristotle overlooked the possibility that a man *may* truly realize himself in a vocation. Also he did not contemplate a social order other than his own,—one in which every man *must* bend himself to a special function, there being normally no provision, on the one hand, for an aristocratic leisure-class which shall be exempt from the necessity of any calling in particular, and, on the other hand, for a servile class doomed inexorably to the dull, deforming round of narrow toil. Lastly, Aristotle and his followers have forgotten that general culture is not gotten through studies in general, but must be worked out by every man along his own line—yea, even if it be his professional line,—and must gain its breadth by being carried so deep and far as to be brought into connection with things and life in all directions. However, if such has been our mistake in the past, just at present we are drifting into notions exactly the reverse. Members of college faculties are breezily advocating the proposition that a man's general culture will take care of itself if he only thoroughly turns his

attention to getting his profession—and then getting his profession is interpreted in the narrowest technical sense. What are we to say to this new doctrine? I for one confess that I am bewildered in the presence of a pedagogical philosophy whereby Plato, Shakespeare, and the New Testament become educational aberrations, or something to be consigned to private reading-circles and the Sunday schools. I still must hold that the very heart of education is general culture—ideas, broad human sympathies, and broad human capacities. In the secondary schools, and in the college itself so far as it continues a part of the secondary school, professional studies have a place only in so far as they are soundly reconcilable with the more vital concern of culture. They have even less right there than have the vulgarer useful studies in the lower schools, because they are not a concession to an urgent need of getting a living. The proper place for strictly professional studies—for the preparation of doctors, lawyers, bankers, foresters—aye and teachers too, is in the graduate and professional school; and even there—as all enlightened judges will urge,—they should be conducted on a broadly liberal foundation, with a broadly liberal outlook.

In conclusion, let us summarize quickly. The aim of the secondary school properly is and must remain culture. However, the hostility of practical and professional studies to culture is not so great as has, under the influence of tradition and false aristocratic feeling, been too usually assumed. Furthermore, this incompatibility may, by enlightened teaching, be still further diminished—to the benefit of the useful and professional knowledge itself. Lastly, in the working out of these matters, at any rate in the more popular schools, it is the distinctively learned subjects that must expect to make most concession, though the serviceableness of these branches themselves to the cultural ends that are at the bottom of the schools, is capable of very large increase.

ENGLISH SECTION

Discussion of English Masterpieces Required for Entrance to College

PRINCIPAL JAMES H. HARRIS, MICHIGAN MILITARY ACADEMY

At the outset permit me to say that my discussion, while including the subject as given above, will take a somewhat wider range, and besides discussing some of the particular books required for college-entrance, will consider some of the principles and conditions which underlie the choice of reading matter, and which should, in a measure, determine the selection.

Last summer in a paper read before the English Section of the Department of Secondary Education at Detroit, I expressed my belief that the adoption of unified requirements in English was a necessary and eminently progressive step in the evolution of the English curriculum. The chaotic conditions that prevailed,—both on the side of the colleges, no two of which made the same requirements, and the secondary schools, where individualism had run mad,—were so subversive of economy of effort and of unified and satisfactory results that it became imperative that the atmos-

phere be clarified, the woful waste of time and energy remedied and the English requirements brought by force into something of unity and order. This step, as I have intimated, was absolutely necessary to the integrity, security and continued effectiveness of the English curriculum, and receives its justification in the unquestioned good it has done in bringing order out of chaos and in attaching some measure of unity and fixity to the work in English. All praise should be given to the Committee on College Entrance Requirements in English which so bravely attacked so serious a problem and so successfully worked it out.

But that step, important and beneficial as it was, can hardly be looked upon as final. At best it was a unity forced, artificial, superimposed. It is not a unity from within, possessing the vitality and permanency of life, but is an artificial unity and only of service as it is a necessary step in the evolution toward the higher unity. For of all the branches of instruction in the program of studies, English is, of force, the most fluent and plastic, the least susceptible to rigidity and inflexibility either in form or content. The time can never come, I believe,—until English takes its place among the dead languages,—*Dei diem avertant!*—when the curriculum in English can be as determinable, as restricted, and as final as in the Ancient Languages or in Mathematics. The ends and aims of instruction may, and, I believe, will be more clearly defined, but the means by which those ends are attained will ever vary. So long as English is a living tongue the attempt to give rigidity and permanency to the curriculum cannot but fail. The very term "College Entrance Requirements" indicates at once the source, the strength and the weakness of the existing situation. It is the ever-present witness to the fact that the unity is imposed from without. In a time when the colleges and universities are less and less given to imposing their will upon the secondary schools, we find the rather anomalous condition of a consciously imposed curriculum. Yet it was a necessary imposition, and a situation which the secondary schools seemed unable to cope with alone had to be taken in hand by those in the higher institutions. This is a source of strength, but it is also, as I have intimated, a source of weakness, and the time must come when the problem will be solved from within on the basis of a sound psychology and of sound logical and historical principles. What I mean by this will appear from a study of the conditions which gave rise to the necessity for the interposition of higher authority to bring into order a distinctly chaotic condition. Those conditions were, first, a hazily defined curriculum; second, an absence of specially trained teachers; third, an inadequate time allowance; fourth, the difficulty of fitting students for a most varied assortment of entrance requirements; and fifth, a lack of suitable texts suitably edited. Out of these conditions grew the necessity for collegiate interference and guidance. But these imperfect conditions are in some particulars wholly remedied, in others rapidly becoming so. We are attaining a more definite conception of the end and purpose of our English instruction; we are granting it a larger allotment of time; we are equipped with numerous and suitable texts—good tools with which to carry on our craft;—we are strengthening our course of study; and above all—and the underlying strength of all—we are securing a body of teachers trained for this work as are those in the Foreign Languages, in Science and in Mathematics. With the removal, by a natural process of growth, of the conditions which brought about the imposed curriculum in English, we may look for a reconsideration of its

claims to permanency, and discover whether, in the light of the new conditions, certain modifications may not be necessary and some revision of the principles upon which it is based be formulated.

The basis, then, of the reconstruction I have in mind lies in the thought of an inner unity as contrasted with an outer, artificial unity. I acknowledge that the superimposed unity is easier; it relieves us from all care and responsibility; it says 'do this' and we do it:

> "Ours not to reason why,
> Ours but to do or die;"

it makes us secondary clay in the hands of the University potter, and while it may manifest the surpassing artistic cunning of the potter, it,—well, it makes and keeps us just clay!

The elements of this inner unity are three in number, and out of them, I believe, the English curriculum will ultimately be constructed. These elements will be determined, first, by a wide and comprehensive study of the tastes, interests and intellectual attainments of the pupils of secondary age; second, by an exhaustive and scientific study of the books and literature adapted to each particular grade or age; and third, by a study of the principles underlying the historical development of literature. If a course of reading based on such a sound philosophy and psychology as this could be elaborated, the inner unity for which I plead would be attained and the most satisfying results would be achieved. The question of adequate preparation for college, too, would solve itself, and the pupil who was best prepared for life on such a program would of necessity be best prepared for college. We hear much about the best preparation for college being the best preparation for life, but I say the best preparation for life is the best preparation for college.

A PLEA FOR WIDER OPTIONS IN READING MATERIAL

But for the present my first practical application of the theory that the English curriculum must be built up from within and must rest on a study of the conditions and factors that are predominant in the secondary school period, is the recognition of the principle of wider options in our reading material. But, you will say, that involves a reversion to the chaotic, disorderly individualism of the days which we are glad to think are no more. No, I do not mean such a wide-open policy as formerly prevailed; I mean freedom within certain well-defined limits; I mean that instead of four books absolutely and undeviatingly required there should be a list of eight or ten books from which choice might be made; I mean that instead of ten books for general reading, a list of twenty-five should be made within which the teacher might select those best adapted to local or individual conditions or most consonant with his or her own interests, tastes and studies. I am well aware that teachers of sufficient training, literary taste, breadth of view and good judgment to select what is best on any scientific principles, without reference to some idiosyncrasy or one-sided interest, are extremely rare. And to leave complete freedom to these would be to invite a return to those conditions which we all so much deplored. But selection within such limits as I have suggested would, on the one hand, sufficiently safeguard the interests of the curriculum, and, on the other hand, give adequate freedom to that growing class of teachers, who, with a splendid equipment in English, are sanely judicious enough to use the restrictedly wider opportunity to the enrichment of their own souls, the

enlargement of the mental horizon of the pupils and the betterment of the curriculum. To many a well endowed and adequately trained teacher the narrow restrictions of the College Entrance Requirements are a source of baffling discouragement. Seeing the rich feast before their eyes, like Tantalus, they may not taste of it. Shall they constantly be so tortured? Out of the surpassing richness of our unrivaled literature are there only four books which can be carefully studied to advantage and profit? Shall the whole fabric be sacrificed to convenience? The number of books constituting the body of good and imitable literature—literature which it is not only worth the pupil's while to absorb, but which he is prepared to absorb—is so large, and the line of cleavage between the one gem of literature and the other is so fine that it is out of the question to reject the one and insist on the other, save on the assumption of an artificial convenience and a forced requirement.

This leads me naturally to consider the claims of some of the books which are set for careful study and general reading, and to raise the question, *not* whether they should be discarded but whether a wider option might not be allowed. I have no thought in my mind to question the claims of the books recommended, to a place in the hierarchy of English masterpieces. Every one of them is admittedly included in that sacred circle and I would not wish to seem even to question the claims of these masterpieces to a place in that list. I shall merely consider one or two of them in the light of their adaptability to secondary school conditions and their claim to *exclusive rights* as the objects of literary study.

The first masterpiece to which attention is called is Tennyson's Princess. While it is true that this poem is not included in the list for careful study, it is included in the list for general reading, and must perforce be given a place somewhere in the curriculum to the exclusion of something else. There is no question of the artistic greatness of this poem, and some of the intercalary lyrics, notably "The splendor falls on castle walls" and "Tears, idle tears, I know not what they mean," are among the most beautiful in English literature. But why wade through an interminable discussion of the equality of the sexes in order to get a few gems? To boys especially the task of toiling through this long poem is discouragingly dreary and there is great danger of creating in them a distaste for the master poet of English form and versification which they may not ever overcome. It would seem to me that the approach to Tennyson might more happily be made through other avenues.

The second masterpiece for which an option might very reasonably be offered is Burke's Speech for Conciliation. Not that I would exclude it from the list, for its historical as well as its oratorical value amply justify its selection as an example of the form of literature of which it is so splendid a representative, but there might be conditions which would make the selection of another piece of oratory more serviceable, and for the benefit of these an oration of our own Daniel Webster or Wendell Phillips might well be substituted. To drag a class largely composed of girls, for instance, whose argumentative stock in trade usually consists of one word, thro' Burke's elaborate and often fine-spun arguments, is a task to test alike the patience and the wits of the most dauntless teacher.

The cultivation of a style like Burke's would be an anachronism. Why then devote so much time to it or lay so much stress upon it? In the study of Burke the teacher is much of the time warning his class against

his florid diction, his rhetorical digressions, his effusive classicism. No speaker of this day would think of constructing a speech in imitation of Burke. The whole spirit and atmosphere of modern times calls for oratory —even argumentative oratory—of an entirely different type. Again, it requires mature and trained thought to follow Burke's involved argument, and it is doubtful whether, unaided, the average boy or girl in our secondary schools would be able to give an outline of it. And I am inclined to think, as a result of experience and observation, that a practical example of argumentation less complicated and less ornate would better accomplish the purpose in many instances.

I have no thought, let me repeat, of decrying the greatness or importance of the speech. It is one of the masterpieces of one of England's master orators. But I would question the propriety and value of forcing a lot of boys and girls thro' it, especially under a teacher whose appreciation of closely reasoned and logically constructed argument is circumscribed by sex. I should place the oration in the list of books for careful study, but make it optional with one or two other orations such as those suggested above, and let the individual teacher's judgment determine whether it is the best book for careful study with that particular class.

Another bit of literature I should venture to raise some question about is Milton's Comus. Not but that the poem has literary and artistic excellence of a high degree, and moral tone of an unimpeachable character. The trouble is the poem is so flagrantly and flauntingly moral that it vitiates the art.

I have not time to enter into further detailed discussion, but I cannot close without referring to the conspicuous lack of American masterpieces on the list. I am far from being so scoundrelly in my patriotism that I see nothing good in other than the American brand. At the same time one cannot be charged with extravagant patriotism in claiming that at least five or six of our writers are deserving of recognition.

To sum up, then, I would plead for a list of ten books instead of four among those recommended for careful study, from which the teacher might select the four best adapted to her needs and tastes. I would favor a list of twenty-five books for general reading, selected with some reference to historical sequence and to the interests and attainments of the pupils, and in doing that I could not but include at least a few of our American authors. In this way, I believe, we would secure sufficient rigidity to satisfy the convenience of college-entrance examinations and at the same time give sufficient flexibility to the curriculum to broaden the interest and stimulate the activities of our best teachers.

Composition Teaching in the Schools of Mississippi

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It is a significant fact that President Eliot speaks of the introduction of systematic instruction in the English language and literature into the secondary schools as a "tendency." "It may be spoken of," says he, "as a tendency, because the best methods and legitimate aims of this instruc-

tion are still under discussion, and are still being developed by continuous experiments in innumerable schools.'' However disposed we may be to resent the word ''tendency'' in this connection, a very little consideration of the question will show that President Eliot is right. Though the study of English is now receiving more attention in the secondary schools than ever before, yet the methods and aims are so varied that we must still call the whole movement a tendency rather than an assured triumph. Both of the constantly recurring questions in pedagogics, ''What shall I teach'' and ''How shall I teach it,'' have been answered in substantially the same way by all teachers of Latin, Greek and Mathematics. In English, however, there is a wide divergence of views as to the proper answer to each. In no other department of study, perhaps, has the teacher freer play for his personality, and greater opportunity, therefore, for the display of originality, and, I may add, of eccentricity. But in education, as in government, excessive individualism is as dangerous as a mechanical uniformity. The ideal educational system is an organic whole. It may not be unprofitable, therefore, for us to consider again the much discussed question of English composition teaching.

The ideas advanced in this present paper have been put into shape after an investigation of the methods and aims in the teaching of English, especially composition, in the secondary schools of Mississippi. This investigation was made because my contact with themes written by college students had brought me to the conclusion that, since the schools were not achieving success in this line of work, there must be something wrong in the methods used. This belief led me to prepare a set of questions to be answered in writing by all Freshman students in the University of Mississippi. These questions touched upon their preparation in grammar and spelling, in composition and rhetoric, and in reading the prescribed masterpieces. I carefully read the ninety-four sets of answers, representing in all forty-two schools, and took full notes of their contents. In this way I gained an insight into school methods which could not have been gained in any other way. Though I believed that the students had answered the questions in perfect good faith, in order to make assurance doubly sure, I verified the information obtained by inquiries made of principals and teachers in the secondary schools. Hence I believe the picture I present is a just one.

Let us see what the conditions in regard to composition teaching are. The first general conclusion that would be drawn from these papers is that the schools taken collectively do not exhibit any uniformity in their English instruction; they differ widely in quantity of work done, in quality, and in their estimate of the ultimate object of instruction. The question, ''How many of the prescribed English masterpieces were read in direct preparation for college?'' drew forth a great diversity of answers ranging from ''all read'' to ''none.'' Many said that they had read a few of the masterpieces and parts of some others. From the answers to other questions it was evident that in only a few schools was there even the most superficial connection between the literature study and the composition work. Here is an answer which gives, it seems to me, the average situation: ''I read some of the required books merely for the substance and the pleasure I could get out of them, and did not make them a study, so of course they were not explained to me or discussed by me in class, and I never made them the subject of a written exercise.'' Another wrote: ''Each work

was read entire, and special stress was given to word study and derivation and telling the figures of speech. The works were used as a subject in written exercises.''

The answers to the question: ''How much time was spent in your school in English composition? What was the length in words, approximately, of each written exercise?'' exhibit great diversity and weakness. One student writes: ''It was every day (30 m. recitation) two terms one year, and our essays were 800-1000 words.'' It is almost impossible to tabulate the answers to this question. For this the schools, in a great measure, are themselves responsible. They represent extremes. Some schools spread the instruction in composition over the entire course, giving a moderate amount each week. Others, again, seem to concentrate all the composition work into one year. But of all the schools, except a very few, it would be perfectly safe to say that the aggregate amount of work is quite inadequate. The general rule seems to be that the difficult art of writing the mother tongue is to be taught by having perhaps only one hour each week devoted to it, and by requiring pupils, once every month or two, to perform the drudgery of writing a long 1000-word ''composition.''

The answers to the question ''Did you study any text-book of rhetoric? What was the nature of the instruction?'' were confusing. Very many students answered as if rhetoric was an entirely distinct subject from composition, something to be studied on its own merits without regard to their writing. This conception is inevitable, one may say, in a school that disposes of rhetoric in a term or two by recitation only or mainly.

Some remarkable answers were given to a question about the kinds of subjects on which students had been required to write. Thus one writes: ''Subjects were usually given us by the teacher; e. g., 'Bees,' 'Character,' 'Napoleon Bonaparte,' 'Mountains,' 'The Last Time I Went Fishing,' 'How I Spent My Vacation.''' Another says: ''Our subjects were chiefly argumentative, or on some current topic of interest: 'Temperance vs. Total Abstinence,' 'Canada should be annexed,' 'Our War with Spain,' 'Fairies,' 'Rats,' etc.'' I do not believe the answer was intended for an anti-climax.

To the last question asked: ''State any other facts that may aid in forming an estimate of the work actually done in English in preparatory schools. How much time and attention did English receive in comparison with other subjects? Were your written exercises or examination papers in mathematics, Latin, history, etc., corrected for faults of spelling and expression?'' the answers were in the main not clear. Evidently not many of the writers were accustomed to summing up the operation of a study running through more than one year, and their memories failed them. The inability betrays, I think, a defect in the training itself. The same writers would have done better if asked to recapitulate their course in Latin or mathematics. The answers to the second part of the question: ''How much time and attention did English receive in comparison with other subjects?'' were in three groups. One group maintained that English received fully as much attention as any other study and justified the assertion by the superior quality of the papers. Another group took the same ground but denied the assertion by writing extremely poor papers. The third group, the great majority of the class, were either noncommittal or inclined to the view that English did not get an equal share of attention.

To the last part of the foregoing question: ''Were your written

exercises or examination papers in other studies corrected for faults of spelling or expression?'' very few gave satisfactory answers. Many gave no answer at all. Some stated that occasionally a fault in spelling (but not in expression) had been corrected in such written exercises. Only a very few were able to give the assurance that their general school work had been thoroughly corrected for poor English. Such are some of the facts.

One general conclusion, I think, must be drawn from these papers. Or rather, one general conviction forces itself upon the reader. It is that the work in English composition is not giving satisfactory results. What is the remedy for the failure on the part of the secondary schools in this respect? The schools have the remedy in their hands, but many of them fail to see it because, like most genuine remedies, it is very simple. Perhaps it has been overlooked or misapprehended precisely because it is so simple. Were it more complex or more mysterious, it might succeed better in commanding regard. The remedy consists, to put it into a short phrase, *in changing school English from a study into an art*. The teachers of composition have forgotten the commandment: ''Thou shalt always hold practice primary in thy teaching of composition; theory thou shalt regard as only secondary.'' This, broadly speaking, is the cause of the failure, so far as it may be called a failure, in teaching composition. For convenience in applying the remedy, we may, in our diagnosis, attribute the ailment to three causes: 1, The essays required are too infrequent and too long; 2, the distinctive function of composition work is not regarded; 3, the printed page is not made the supreme teacher of composition. Taking up these reasons in the order of their statement let us attempt to make some suggestions by which matters may be improved. I am sure that no true teacher in Mississippi would deny that the only royal road to success in composition is to practice writing, and I am equally sure that many teachers yearn to follow this method in their schools. But they are handicapped by difficulties of several kinds, two of which, at least, will at once suggest themselves: 1, The pupil does not have time or inclination to write as many compositions as his teacher knows he ought to write; and, 2, the teacher does not feel that he has time to correct as many exercises as the pupils ought to write. Yes, English composition is one of the bugbears of teachers and pupils alike. The pupils find talking so much easier than writing that the latter seems a wanton retardation of utterance; while the teacher inwardly sighs as he sees the composition papers piling up and reflects on the unmitigated tedium of correction that is in store for him. Indeed, many a teacher wears himself out correcting papers and is nevertheless forced to look back over the work of the session with feelings far from complacent. And yet, no faithful and observant teacher can doubt that pupils learn to write only by writing; and that it is the duty of the teacher to correct rigidly every written page that the pupil submits. The difficulty in the whole matter, I think, lies in the fact that the compositions demanded are not too many, but too long. We expect the pupil to write a composition as soon as he has learned to write a sentence. In other words, we try to pass from the sentence to the composition, making the sentence the unit of composition. The unit of composition (a composition being a structural aggregate) is the paragraph. We should pass, therefore, from the sentence to the paragraph, then to the composition proper. Drill the pupil in the paragraph, which is nothing more than a

cluster of sentences dealing with a single topic. Let the paragraphs be short, not more than ten or fifteen lines at first, but see that they have unity and symmetry. Spend months on this; for the paragraph is the composition in miniature.

In other words subdivide your topics into small parts and drill on each separately. Let me illustrate. Suppose you desire a composition on "A Day's Hunt." Let the pupils write separate paragraphs on: 1. How I Longed for the Day to Come; 2. The Start; 3. My Companions; 4. Our Dogs; 5. The First Game; 6. A Bad Shot; 7. A Shower; 8. Our Lunch; 9. An Accident; 10. Something Funny; 11. What We Killed; 12. Our Return.

Now if these paragraphs or miniature compositions are short, the teacher can correct them not only with less expenditure of time but with more efficiency than if four or five pages had been written. After a drill in this way, assign the entire topic, "A Day's Hunt."

Great difficulty is sometimes found in securing and assigning appropriate topics. The difficulty chiefly arises from failure to remember the distinctive function of composition teaching. The aim is not to give the pupil information on the topics chosen, but to teach him how to arrange and present the information already in his possession. I am speaking always of secondary work, not of the collegiate period when the student may sometimes fairly be expected to "work up" a given subject. Topics, therefore, about which the student is ignorant should not be assigned, even though the source of information be ready at hand. Exercises in composition should not be intended to teach new facts, but to teach how to systematize and present facts already known. The difference is that between gathering flowers and arranging them into bouquets. The pupil is supposed to be culling from every book that he studies, to say nothing of the wider fields of experience and observation; but work in composition has as its distinctive function the orderly arrangement and expression of thought won from any field whatsoever. I emphasize this because I believe that just in proportion as the pupil has to collect information upon his topic to that degree he expends the time and thought that should have been put upon arrangement and expression.

I have said that composition differs from other subjects in that it deals not with amassing information, but with presenting it. Let me mention one other distinction, which is at the same time an advantage, which gives the teachers of English composition finer opportunity than the teachers of any other department have. It is this: every page of print that the pupil reads, every book that he studies, may be made to contribute to the correctness of his style. Whether it be arithmetic, geography, history, or botany, if he has inculcated in him the habit of close scrutiny of the written page, he is daily absorbing the principles of spelling, capitalization, punctuation, sentence structure, and paragraphing. This gives the teacher of English an incalculable advantage, due solely to the fact that all the information that the text-books yield must reach the pupil through the medium of written English.

This consideration, therefore, should largely control the teacher's method of dealing with composition work. He should strive to develop in the pupil, at the earliest possible stage, the habit of close observation of what he reads. The problem is to establish such a relation between the pupil and the written page that every book read shall contribute to his

knowledge of correct form. I make a plea for a more fundamental use of literature in composition teaching than the connection ordinarily made now between the two—the mere drawing of subjects for compositions from the books read. Just as the mineralogist sets an assortment of minerals before his pupils to be analyzed, or the botanist hands them a flower, saying "Examine minutely and report;" so the teacher of elementary English should insist that the pupil *scrutinize* what he reads. The printed page should be to the student of English composition what the mineral is to the student of mineralogy, what the flower is to the student of botany, what the map is to the student of geography, what the insect is to the student of entomology.

If the pupil leaves your schoolroom without having acquired the priceless habit of observation, then you have failed to avail yourself of the distinctive advantage already mentioned; you have failed to make his knowledge of good writing self-sustaining. He may read hundreds of good books without adding appreciably to his store of form, of expression, of correctness in all the details of written English because you have never put him in touch with books as the supreme teachers of composition.

How may we best accomplish this? By selecting topics, whenever possible, from the books that your pupils are using; and by selecting chiefly with the end in view of focusing the pupil's attention upon the spelling, punctuation, paragraphing, and general structure of what he is reading. But before doing this, I have found it of great benefit to have the pupil do no little copying. I do not believe that twenty-five per cent of the students in the freshman classes of our colleges can sit down to a page of conversational English and copy rapidly without error. It demands an eye open to everything on the page; it inculcates, if kept up, habits of scrutiny that will serve the pupil in every department of effort; above all it tends to make him depend for correctness more on observation and less on memorized rules; it develops the inductive sense and leads the pupil gradually to see that the rules of correctness in writing are nothing more than attempts to formulate into a system the uniform practice of good writers; and, lastly, it makes the pupil's skill in composition grow as a rolling snowball grows,—by attaching to itself what it comes in contact with.

No study of formal grammar, no acquaintance with rules or text-books, can take the place of constant scrutiny on the pupil's part of what he reads. Indeed, until the habit of close observation has been established, books on composition amount practically to nothing.

Perhaps you may ask, "Will not this unremitting attention to details that are merely formal and external divert the pupils' minds from literary beauty? By no means. You must keep it up until it becomes a second nature to the pupils, until it ceases to be an effort; just as walking, skating, dancing soon cease to be the awkward displays that they at first were. Surely Benjamin Franklin's style was not injured, nor was his literary sense dulled by his technical knowledge of type-setting and proof-reading. Shakespeare was not a worse dramatic writer because he was an actor and knew all the formal details of his craft. Whatever awkwardness may appear at first will pass away as soon as this attention to the minutiæ of composition shall have become an ingrained habit. Besides, in insisting that your pupils use their own eyes and make the attempt to formulate their own principles of expression, you are teach-

ing English composition exactly as all scientific branches are taught today. If there is one tendency in pedagogy that cannot be mistaken by even the most casual observer of methods, it is the tendency toward having the pupils learn at first hand. There are too many *media* interposed between the learner and the thing to be learned. The old way was to lead the pupil all around a topic, but rarely, if ever, to let him put his hands on it. Modern methods demand that he get a hand grip on it at once, and then circle around it to his heart's content.

Let me return, by way of conclusion, to the subject of topics. After a drill in mere copying, assign topics from some literary masterpiece that your pupils are reading. If, for example, it be "Rip Van Winkle," I should have them ascertain and write down in their own words the subject of each paragraph in the story. I should then assign, with books closed, one of these paragraph subjects as the topic for an exercise in reproduction. Keep this up, day by day, until every important paragraph shall have been reproduced in their own words. Then take the leading characters: Rip, his wife, his son, and Nicholas Vedder. Assign these in like manner as paragraph topics. Such exercises soon beget in the pupil the habit of minute observation, not only of the features of the story, but equally of the general details that constitute correct writing. His vocabulary will almost insensibly be enlarged. The certainty that he will have to reproduce in writing what he is reading will soon implant the habit of scrutiny; and when this is done the pupil is on the road to assured mastery in English composition.

It is needless to say that I do not advocate holding the pupil back in his reading of English literature until every masterpiece shall have been treated in this way. I except, also, poetry from the material proper for drill in composition. Select only prose, and the simplest prose possible. Irving, by the way, is far from being the best writer for reproduction exercises. In a word, I am not presuming to dictate authors, topics or method; but I do urge you, fellow teachers, to lay supreme emphasis on the development of the pupil's own powers of observation, remembering that these are just the powers that are now most active. Select any method that will lead to this goal, but keep this goal always in sight.

MATHEMATICAL SECTION

Some Recent Discussion of the Teaching of Mathematics

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I was led to select this topic for this afternoon by the fact that at the Glasgow meeting—held last year—of the British Association for the Advancement of Science, the section on mathematics and physics and the newly organized section on education had a joint session at which the principal paper was read by Professor John Perry of the Royal College of Science, London. This paper, as was intended, provoked a good deal of

discussion, which was followed by the appointment of a representative committee with Professor Forsyth of the University of Cambridge as chairman, "to report upon improvements that might be effected in the teaching of mathematics, in the first instance in the teaching of elementary mathematics, and upon such means as they think likely to effect such improvements." Professor Perry's paper was published in the *School World* for October, 1901, and the accompanying syllabus in the November number of the same journal. Later Professor Perry edited a book of one hundred pages, published by the Macmillan Co., containing his address, syllabus, reports of the discussion, together with written remarks from fourteen mathematicians and teachers of prominence who were not present at the meeting, and a reply by himself. I may add that the address was given in full in the *Educational Review* for February, 1902.

This discussion of the teaching of mathematics in England particularly with regard to the retention of Euclid as a text-book of geometry is by no means a new one. De Morgan, one of the best teachers of mathematics England ever had, in his article on "Mathematics" in the Penny Cyclopedia, and in substance in other places, says: "The work of Euclid is preferable in our opinion to any system which has been proposed to supply its place: simply because the dependence of conclusions upon premises is more distinct than in any other geometrical writing. The defects with which it abounds (and DeMorgan was both logician and mathematician enough fully to appreciate them) are trifles which can be remedied as they are met with; and though there are seldom three propositions together, one or other of which will not call for some remark from the teacher, yet such is Euclid that these very faults properly noted, are of more value than the greater elegance and more artificial process of less formally vigorous writers." On the contrary, Sylvester, whose enthusiasm bred contagion wherever he taught, whether in England or America, in words often quoted from his presidential address to the mathematical and physical section of the British Association in 1869, says: "I should rejoice to see mathematics taught with that life and animation which the presence and example of her young and buoyant sister (natural and experimental science) could not fail to impart, short roads preferred to long ones, Euclid honorably shelved or buried 'deeper than ever plummet sounded,' out of the school boy's reach, morphology introduced into the elements of algebra—projection, correlation and motion accepted as aids to geometry—the mind of the student quickened and elevated and his faith awakened by early initiation into the ruling ideas of polarity, continuity, infinity, and familiarization with the doctrine of the imaginary and the inconceivable." He confesses: "The early study of Euclid made me a hater of geometry . . . and yet in spite of this repugnance, which had become a second nature in me, whenever I went far enough into any mathematical question I found I touched at last a geometrical bottom." Again, Todhunter, the teacher, examiner and English mathematical text-book writer *par excellence*, in a 56-page essay on Elementary Geometry, wields the cudgels most vigorously in favor of a strict adherence to Euclid. He suggests that the grounds of Sylvester's dislike may have been "only the repugnance which might naturally be felt by a creative mind conscious of the power to advance without any superfluous aid," and says: "Tradition seems to record such characteristics of Newton and Pascal. It would be unwise, however, to suppose that such exceptional cases are likely to be common."

The opposition to Euclid in England seems first to have taken definite form in the organization in the year 1871 of the Association for the Improvement of Geometrical Teaching, whose object, as stated in the Code of Rules, "shall be to effect improvements in the teaching of elementary mathematics and mathematical physics, and especially of geometry." This association has published a syllabus of plane geometry, a syllabus of modern geometry, and a text-book entitled Elements of Plane Geometry; but by reason of the undisguised hostility of various boards of examiners, it has accomplished comparatively little. The present revival of the discussion is due to the untiring activity and zeal of Professor John Perry, whose charming naiveté is not concealed even in his text-book on the calculus. For twenty-odd years, in season and out of season, with reason, and sometimes, I fear, without reason, he has preached on "England's Neglect of Science," "The Defects in the Teaching of Mathematics," and similar subjects, till finally he secured a hearing before the two sections of the British Association in September, 1901. As early as July he notified those who were expected to take part in the discussion, of the date assigned for the reading of his paper, September 16, and had copies of his paper printed for distribution before the meeting; but a change to a date three days earlier was found imperative, so that some of the expected speakers did not reach Glasgow in time, while those who were present did not have the wished-for opportunity carefully to examine the paper before the discussion. Still the written remarks from various contributors now published with the address, render this change of slight consequence.

Professor Perry was very much in earnest. He begged his auditors to give him the benefit of their severest criticism and advice, and said: "Anybody who thinks I am making a mistake, or who sees how my method may be improved, and who holds his tongue, is doing a real harm to the country." As would be expected from a teacher in a technical college, Professor Perry is a staunch believer in the utility of mathematics. The obvious forms of usefulness in the study of mathematics he enumerates as follows:

"1. In producing the higher emotions and giving mental pleasure. Hitherto neglected in teaching almost all boys.

2. (*a*) In brain development. (*b*) In producing logical ways of thinking. Hitherto neglected in teaching most boys.

3. In the aid given by mathematical weapons in the study of physical science. Hitherto neglected in teaching almost all boys.

4. In passing examinations. The only form that has not been neglected. The only form really recognized by teachers.

5. In giving men mental tools as easy to use as their legs or arms, enabling them to go on with their education (development of their souls and brains) throughout their lives, utilizing for this purpose all their experience. This is exactly analogous with the power to educate one's self through the fondness for reading.

6. Perhaps included in (5): in teaching a man the importance of thinking things out for himself and so delivering him from the present dreadful yoke of authority, and convincing him that whether he obeys or commands others, he is one of the highest of beings. This is usually left to other than mathematical studies.

7. In making men in any profession of applied science feel that they

know the principles on which it is based and according to which it is being developed.

8. In giving to acute philosophical minds a logical counsel of perfection altogether charming and satisfying, and so preventing their attempting to develop any philosophical subject from the purely abstract point of view, because the absurdity of such an attempt has become obvious."

He believes most sincerely that these desirable functions would be performed well under the new system which is suggested. It may be well to quote a characteristic passage: "The ancients devoted a lifetime to the study of arithmetic; it required days to extract a square root or to multiply two numbers together. Is there any great harm in skipping all that, in letting a boy learn multiplication sums, and in starting his most abstract reasoning at a more advanced point? Where would be the harm in letting a boy assume the truth of many propositions of the first four books of Euclid, letting him accept their truth partly by faith, partly by trial? Giving him the whole fifth book of Euclid by simple algebra? Letting him assume the sixth book to be axiomatic? Letting him, in fact, begin his severer studies where he is now in the habit of leaving off? We do much less orthodox things. Every here and there in one's mathematical studies one makes exceedingly large assumptions, because the methodical study would be ridiculous even in the eyes of the most pedantic of teachers. I can imagine a whole year devoted to the philosophical study of many things that a student now takes in his stride without trouble. The present method of training the mind of a mathematical teacher causes it to strain at gnats and to swallow camels. Such gnats are most of the propositions of the sixth book of Euclid; propositions generally about incommensurables; the use of arithmetic in geometry; the parallelogram of forces, etc.; decimals. The camels I do not care to mention because I am in favor of their being swallowed, and indeed I should like to see them greatly increased in number; these exist in the simplest arithmetic, and geometry and algebra. Why not put aside ever so much more, so as to let a young boy get quickly to the solution of partial differential equations and other useful parts of mathematics that only a few men now ever reach? I have no right to dictate in these matters to the pure mathematicians. They may see more clearly than I do the necessity of a great mathematician going through the whole grind in the orthodox way; but, if so, I hardly see their position in regard to arithmetic and other things in the study of which they do allow skipping. I should have thought that the advantage of knowing how to use spherical harmonics or Bessel functions at the age of seventeen, so as to be able to start in mathematics at Cambridge just about the place where some of the best mathematical men now end their studies forever, of starting at this high level with youthful enthusiasm, and individuality, and inventiveness, would more than compensate for the evils of skipping."

The first part of the syllabus, and the only part we shall take up, is entitled "A Course of Elementary Mathematics. A course of study recommended for training colleges and for boys and girls."

"*Arithmetic.*—Decimals to be used from the beginning; the fallacy of retaining more figures than are justifiable in calculations involving numbers which represent observed or measured quantities. Contracted and approximate methods of multiplying and dividing numbers whereby all unnecessary figures may be omitted. Using rough checks in arithmetical

work, especially with regard to the position of the decimal point.

The use of 5.204×10^5 for 520400, and of 5.204×10^{-3} for .005204. The meaning of a common logarithm; the use of logarithms in making calculations involving multiplication, division, involution and evolution; calculation of numerical values from all sorts of formulæ however complex.

The principle underlying the construction and method of using a common slide rule; the use of a slide rule in making calculations. Conversion of common logarithms into Napierian logarithms. The calculation of square roots by the ordinary arithmetical method. Using algebraic formulæ in working questions in ratio and variation. Simplification of fractions. Calculation of percentages, etc.

Algebra.—To understand any formula so as to be able to use it if numerical values are given for the various quantities. Rules of indices. Being told in words how to deal arithmetically with a quantity, to be able to state the matter algebraically. . . . Problems leading to easy equations in one or two unknowns. Easy transformations and simplifications of formulæ, and in easy cases finding any one of several quantities in a formula when the others are given. . . . The determination of the numerical values of constants in equations of known form when particular values of the variables are given. The meaning of the expression 'A varies as B.' Factors of such expressions as x^2-a^2, $x^2-11x+30$, $x^2-5x-66$."

From the paragraph on mensuration I can quote only a few statements, showing how Professor Perry would use experimental methods to test the accuracy of rules. Thus, "Testing experimentally the rule for the length of the circumference by using strings round cylinders, or by rolling a disc or sphere. Inventing methods of measuring the lengths of curves. Testing rules for the areas of a triangle, parallelogram, etc., by use of scales and squared paper." The determination of the areas of irregular plane figures by five different methods, including the use of Simpson's rule and the planimeter. . . . "Rules for volumes of prisms, cylinders, cones, spheres and rings, verified by actual experiment; for example, by filling vessels with water or by weighing objects of these shapes made of material of known density, or by allowing such objects to cause water to overflow from a vessel. . . . Stating a mensuration rule as an algebraic formula, etc."

"*Use of Squared Paper.*—The use of squared paper by merchants and others to show at a glance the rise and fall of prices, of temperature, of the tide, etc. The use of squared paper should be illustrated by the working of many kinds of exercises, but it should be pointed out that there is a general idea underlying them all." Among others he mentions such as the following: "Plotting of statistics of any kind whatsoever, of general or special interest. What such curves teach. Rates of increase.

Interpolation. . . . Probable errors of observation. The calculatation of a table of logarithms. Finding an average value. The method of fixing the position of a point in a plane. Plotting of functions, such as $y=ax^n$, $y=ae^{ax}$, for various values of a, b, and n. The straight line, meaning of its slope, slope of a curve at any point in it.

Determination of maximum and minimum values. The solution of equations."

"*Geometry.*—Dividing lines into parts in given proportions, and other experimental illustrations of the sixth book of Euclid. Measurements of angles in degrees and radians. The definitions of the sine, cosine and tan-

gent of an angle; determination of their values by graphical methods; setting out of angles by means of a protractor when they are given in degrees or radians, also when the value of the sine, cosine or tangent is given. Use of tables of sines, cosines and tangents. The solution of a right-angled triangle by calculation and by drawing to scale. The construction of a triangle from any given data; determination of the area of a triangle. The more important propositions of Euclid may be illustrated by actual drawing; if the proposition is about angles, these may be measured by means of a protractor; or if it refers to the equality of lines, areas or ratios, lengths may be measured by a scale, and the necessary calculations made arithmetically. This combination of drawing and arithmetical calculation may be freely used to illustrate the truth of a proposition. A good teacher will occasionally introduce demonstrative proof as well as mere measurement.'' Then follow some elementary uses of analytic geometry of space and descriptive geometry.

In the very interesting discussion which followed the reading of the paper and the presentation of the syllabus decided objection was made to the strongly utilitarian tendency of a large part of Professor Perry's remarks. Professor Forsyth, in particular, said: ''I must point out what would be a platitude if we were not in discussion, that scientific subjects do not progress necessarily on the lines of direct usefulness. Very many of the applications of the theories of pure mathematics have come many years, sometimes centuries, after the actual discoveries themselves. The weapons were at hand, but the men were not ready to use them. Take the case of medicine, which surely is a practical subject. It owes immense debts to the study of sciences like physiology and bacteriology; yet these have been developed and continue to be developed, along their own lines, without being guided in the direction of immediate application at every turn. Yet independent as has been their development, it is notorious that, perhaps all the more because of their freedom in growth, they have provided new knowledge that is of the utmost importance in the conduct of living processes. Take one last example, the X rays. If any one had been set down, as a practical problem, to take a photograph through solid things, I think the common answer would have been that he was being told to solve an insoluble problem. Yet its solution came from the physicists, indirectly as it were, in the course of researches made to obtain knowledge for its own sake. The knowledge so obtained has subsequently led to wonderful results in its application. Influenced by these examples and by others more directly mathematical upon which I shall not enter, I must decline to accept utility as the main or the sole discriminating test, either in the study or the teaching of mathematics.''

Had I the time I should like to quote from the remarks of several of the other participants, but I shall have to content myself with a few selections.

Lord Kelvin wrote: ''I am overdone with work which must not be postponed, and I am sorry therefore not to be able to write anything on the subject. I think your syllabus was good indeed. It is very like the teaching I had from my father.''

Sir John Gorst, chairman of the joint session, told a unique experience he had in New Zealand in his younger days. He said: ''I taught, or attempted to teach, mathematics to the Maori boys and men. As far as the teaching of arithmetic went I taught on a sort of embryo Sonnenschein

principle, and I found them remarkably apt and quick pupils. They learned the practical arithmetic, which was useful to them in actual life, and they learned it with extraordinary rapidity— far faster than boys or men would generally learn it in this country. But when in my youthful enthusiasm I proceeded to try to teach some of them Euclid, or rather geometry after the Euclid fashion, I absolutely and entirely failed. There was not one of them that could grasp or understand the simplest of the propositions of Euclid. . . Had I had the advantage of the discussion to which I have listened to-day, I should have abandoned teaching in the ordinary way until they had been familiarized with angles, lines, areas, and geometrical figures, of which the Maori youth was absolutely ignorant. I suppose by a method of that kind even the least developed intellect of the uncivilized native of New Zealand might have been brought to take in some of the very simple propositions of geometry.''

Professor Everett said: ''The teaching of geometry has been too prosaic. The minds of boys and girls are not ripe for dealing with abstractions. The way in which Euclid begins (especially if the whole body of definitions is taken first) gives the learner the impression of a castle in the clouds.

A moderate amount of practical geometry should come first, including methods of bisecting angles and lines, drawing lines at right angles, making a triangle with sides of prescribed lengths, and inscribing a regular hexagon in a given circle. This will give the learner definite conceptions, and help him to feel that he is on solid ground.

Side by side with Euclid, or a substitute for Euclid, verification by actual measurement of carefully drawn figures should be encouraged. It is useful as a test of the accuracy with which measurements can be made by the methods employed, and also useful as a check against mistakes—which are liable to be made in abstract reasoning as well as in other matters. One of the most important habits in scientific investigation of all kinds is the habit of testing the correctness of one's conclusions by independent methods; and this habit should be inculcated by assiduous practice, as an important element in personal character—an element inseparably associated with the honest pursuit of truth. . . .

The learner should be taken on, as quickly as is consistent with intelligent progress, to the higher branches of mathematics. . . .

The elementary conceptions of the infinitesimal calculus and its simpler processes, should be introduced at an early stage in mathematical teaching.

Another subject that is too long postponed is solid geometry. It is postponed so long that most boys do not get it at all. Considering that we live and move in space of three dimensions, it is unreasonable and impractical to confine all accurate thinking and teaching for three or four years to two-dimensional space. The result is to produce an instinctive shrinking from three-dimensional thinking, as if it involved some terrible mystery.'' I wonder what Professor Everett would think of the method now coming into vogue in Italy of teaching plane and solid geometry together from the beginning! Professor Everett's remarks are so good throughout that I should like to quote further, but time will not permit. I will hasten on to Professor Perry's summing up of the discussion. He says: ''We who have taken part in this discussion have been criticized by some educationists because we have only been expressing well-known educational truths. They forget that, however well-known these truths

may be, they have never yet—never till now—been expressed publicly by more than two or three mathematical teachers. They forget that a reform in the teaching of mathematics was absolutely impossible without the consent and advice of the mathematicians.

It will be found that my syllabus contains almost all the new suggestions which were made by speakers who had no time to study it. (1) Experimental geometry to precede demonstrative. (2) Some deductive reasoning to accompany experimental geometry. (3) Mathematics to enter into the experimental science syllabus as much as possible. (4) Rough guessing at lengths, weights, etc., to be encouraged. (5) Recognition of the incompleteness of any external examination. (6) The importance of familiarizing a boy with problems in three-dimensional space. (7) A hard and fast syllabus undesirable; even the sequence of subjects to be left to a good teacher's initiative.

Further on Professor Perry rather nonchalantly says: "On the whole, I think it may be said that I am in accord with every one of my critics, but of course I know that they cannot unreservedly agree to the adoption of my syllabus as it stands for every kind of student. At all events it is quite evident that there is unanimity in the desire for an immediate large reform in the teaching of mathematics.

I have long known that there is this unanimity among educationists generally, but it is unexpected to find it among the great mathematicians, and the most important teachers of mathematics. I take it that we are all agreed upon the following points:—

1. Experimental methods in mensuration and geometry ought to precede demonstrative geometry, but even in the earliest stages some deductive reasoning ought to be introduced.

2. The experimental methods adopted may greatly be left to the judgment of the teachers; they may include all those mentioned in the elementary syllabus which I presented.

Some of the things for which I contend were put so prominently forward that, if speakers did not object to them specifically, they may almost be taken as agreed to. They are such things as these that follow. Most of them are agreed to specifically by about half my critics.

3. Decimals ought to be used in arithmetic from the beginning.

4. The numerical evaluation of complex mathematical expressions may be taken up almost as part of arithmetic, or at the beginning of the study of algebra, as it is useful in familiarizing boys with the meaning of mathematical symbols.

5. Logarithms may be used in numerical calculation as soon as a boy knows that $a^n \times a^m = a^{n+m}$, and long before he is able to calculate logarithms. But a boy ought to have a clear notion of what is meant by the logarithm of a number.

6. In mathematical teaching, a thoughtful teacher may be encouraged to distinguish what is essential for education in the sequence which he employs, from what is merely according to arbitrary fashion, and to endeavor to find out what sequence is best, educationally, for the particular kind of boy whom he has to teach.

7. Examination cannot be done away with in England. Great thoughtfulness and experience are necessary qualifications for an external examiner. It ought to be understood that an examination of a good teacher's

pupils by any other examiner than the teacher himself is an imperfect examination.

I have not much doubt as to the unanimity with which everybody may be said to have agreed explicitly or implicitly to all the above statements. About these that follow I am in more doubt. More than half my critics will, I believe, agree to them all for all students. I think that every one of my critics will agree to allow a judicious teacher a free hand, especially when he knows that his pupils are likely to need the use of mathematics in their other studies, and especially if they are likely to become engineers, —i. e., men who apply the principles of natural science in their daily work.

8. A thoughtful teacher ought to know that by the use of squared paper and easy algebra, by illustrations from dynamics and laboratory experiments, it is possible to give to young boys the notions underlying the methods of the Infinitesimal Calculus.

9. A thoughtful teacher may freely use the ideas and symbolism of the calculus in teaching elementary mechanics to students.

10. A thoughtful teacher may allow boys to begin the formal study of the calculus before he has taken advanced algebra or advanced trigonometry, or the formal study of analytical or geometrical conics, and ought to be encouraged to use in this study not merely geometrical illustrations, but illustrations from mechanics and physics, and illustrations from any other quantitative study in which a boy may be engaged."

Since Professor Perry's report was published the discussion has gone merrily on. By invitation of a member of the British Association committee some twenty-two teachers in prominent English public schools sent in a sketch of the changes they would like to see made. In the treatment of geometry they are of opinion:—

"1. That the subject should be made arithmetical and practical by the constant use of instruments for drawing and measuring.

2. That a substantial course of such experimental work should precede any attack upon Euclid's text.

3. That a considerable number of Euclid's propositions should be omitted, and in particular

4. That the second book should be treated slightly and postponed till III, 35 is reached.

5. That Euclid's treatment of proportion is unsuitable for elementary work."

As to arithmetic, they think it "might well be simplified by the abolition of a good many rules which are given in text-books. Elaborate exercises in vulgar fractions are of doubtful utility; the same amount of time given to the use of decimals would be better spent. . . . Four-figure logarithms should be explained and used as soon as possible. It is generally admitted that we have a duty to perform towards the metric system. This is best discharged by providing all boys with a centimeter scale, and giving them continual exercise in verifying geometrical propositions by measurement. . . . Probably it is right to teach square root as an arithmetical rule. . . . Cube root is harder and should be postponed until it can be studied as a particular case of Horner's method of solving equations approximately."

Passing to algebra, we find that a teacher's chief difficulty is in the tendency of his pupils to use their symbols in a mechanical and unintelligent way. . . . Elementary work in algebra should be made as far as

possible arithmetical. . . . Such an exercise as the plotting of the graph $y=2x-\frac{x^2}{4}$ provides a series of useful arithmetical examples which have the advantage of being connected together in an interesting way. . . Subsequently curve tracing gives a valuable interpretation of the solutions of equations. . . . We think that undue weight is often given to such subjects as algebraic fractions and factors. . . Might not the theory of quadratics be deferred till it can be dealt with in connection with that of equations of higher degrees? . . . Indices may be treated very slightly. . . . Our recommendations in algebra are corollaries of two or three simple thoughts; the object in view being,—to discourage mechanical work; the means suggested,—to postpone the more abstract and formal topics, and, broadly speaking, to arithmeticize the whole subject."

They recommend that this be followed by a type of diluted trigonometry in which only the sine, cosine, and tangent shall be introduced with the two identities $sin\theta^2+cos^2\theta=1$, $tan\ \theta=\frac{sin\theta}{cos\theta}$, afterward returning to formal algebra for "a revision course bringing in literal equations, irrational equations, and simultaneous quadratics illustrated by graphs, partial fractions, and binomial theorem for positive integral index."

At the annual meeting of the mathematical association held in London, January 18, a paper was presented by Professor A. Lodge on Reform in the Teaching of Mathematics. He spoke principally of the teaching of geometry, and said: "I believe we could not do better at the outset than adopt some French text-book as our model. The Americans have done so already.

The chief points in the French text-books are

1. The more orderly arrangement of propositions.

2. The entire separation of theorems from problems of construction, hypothetical constructions being used in proving a theorem.

3. The closer association of a proposition and its converse when both are true.

4. The adoption of arithmetical notions and algebraic processes.

5. The early introduction of simple loci.

6. Insistence on accurate figures drawn by accurate and practical processes.

7 Practice in exercises from the very beginning. Mr. Greenstreet suggests that I should also add:

8. Attention paid to the various phases of a theorem as the figure changes, and (as the student progresses) to the easier forms of generalization.

"The greater part of these improvements could be adopted at once, provided the sanction of the great examining bodies can be obtained." Aye, but there's the rub.

The *School World* for March is a special mathematical number. It contains articles on school mathematics from the university point of view by mathematicians of Oxford, Cambridge and Glasgow, an article on Elementary Trigonometry in Schools, by Professor Mathews; a Review of the British Association Discussion, by Professor Bryan; a paper on the Teaching of Secondary Mathematics, by Professor Minchin; one on the Teaching of Euclid's Elements, by Headmaster Fletcher, together with considerable correspondence. I shall make a few selections from Professor Bryan's review. He says:—

"It may now be taken for granted that some important changes are at the present time desirable in the order of learning mathematics in this country (for I regret to find that so much is being said about teaching and so little about learning), but it is greatly to be feared that, soon after a change has been made, the new system will be found to have its own drawbacks no less than the old. . . .

In the old style of things the use of algebraic symbols was prohibited in examinations in Euclid. Is it not the fact that much greater life and reality can be put into the study of geometry by encouraging instead of excluding the use of algebraic formulæ?"

After giving illustrations he goes on to say:—

"This use of algebra in the study of geometry has the following advantages:—

1. It breaks down the hard and fast line between algebra and geometry.

2. It furnishes the student with a number of easy examples and exercises in geometry. . . .

3. It introduces the beginner in algebra to the use of symbols for representing concrete quantities (lengths, angles, etc.) and to the nature and meaning of an algebraic formula. . . .

. . . Formal blackboard lectures are a very ineffectual means of teaching improved methods to a beginner. Besides being wasteful of time they require him, (i) to listen when the teacher is talking, (ii) to look at the blackboard when he happens not to stand in front of it, (iii) to write down notes of the lectures and (iv) to think of the method of reasoning, all at the same time, and if he fails for a moment to perform simultaneously any one of these four operations he loses the whole thread of the lecture. Hence it is that so many pupils after the most 'thoughtful' lecturing reproduce faulty text-book proofs which they have been warned against by their teachers, but which they can at least 'get up'."

He sums up as follows:—

"The teacher can do very little to reform the teaching of mathematics to large classes of elementary pupils, for, if he departs materially from the methods of the text-books, the learning of mathematics will suffer accordingly.

The text-book writer can do practically nothing to reform the teaching of mathematics, otherwise his books will not sell and other books will be used instead. This is particularly true when faulty methods or inaccurate statements have to be reproduced (as is frequently the case) in order to make a book salable.

The examiner can do much to reform mathematical teaching by modifying the character of his questions so far as this is consistent with his syllabus, and with giving candidates a fair chance of scoring marks.

The governors of educational institutions could greatly reform mathematical teaching by increasing the mathematical teaching staffs and giving mathematics a more prominent place in the curriculum. This must come about sooner or later, and the sooner the better.

There is no royal road to teaching mathematics, for it is impossible for a boy of given capacity to learn more than a certain amount in a certain time, the rate of learning varying with the individual, from zero upwards, and if it be attempted to introduce new ideas too rapidly into the course the result must be a hopeless failure."

The frank confessions and the suggestions for improvement—which we

must assume to be equally honest—found in these discussions throw an unmistakable flood of light upon the mathematical situation in the public schools of England. Held in servitude by the boards of examiners, who will not permit a hair's breadth variation from the order of Euclid's elements, and required to submit to external examinations which serve principally to reveal the malevolent ingenuity of framers of impractical problems, both teachers and pupils groan under a worse than Egyptian bondage. Small wonder that elementary mathematical teaching in England has fallen so far below that of France, Germany, Italy or America!

The probable outcome of this discussion is hard to forecast. That the committee will recommend some substantial changes for the better may reasonably be expected. That it will advise the rejection of Euclid as a text-book is by no means certain, though it would seem as if nothing pedagogically worse than the present teaching of Euclid, without any knowledge of concrete geometry, or any use of rule, compasses, and protractor, could easily be devised.

The process of change, even when once begun, will need at least a generation. Boards of examiners must "put away the evils of their doing from before all eyes and learn to do well."

Teachers will have to be trained by some other method than merely putting new wine into old bottles, and possibly the author in his anguish will be compelled to say, "Oh, that mine adversary had written a book!"

Methods of Attack in Geometry

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Geometry has long been looked upon as furnishing a peculiar and distinct kind of mental discipline. Plato inscribed above the entrance to his school, "Let no one unacquainted with geometry enter here." Today if we are asked why the subject is taught in our high schools we say that aside from the fact that a certain knowledge of geometry, as that concerning areas and volumes, is useful and should be known, it is given largely because it furnishes almost the only examples of pure logic in the high school course, that it teaches the student to consider carefully given data, and to reason from this to accurate conclusions; yet whether the student can do this or not depends largely upon how the subject is taught. If a student of geometry be given an exercise that does not involve familiar figures and theorems, although it may be a theorem in some other branch of mathematics, he is usually helpless in discovering a key to the proof. This shows us how much of what we thought in the geometry class was the result of reason must have been the result of a good memory. Suppose he is given the theorem that "all prime numbers are either of the form $6n+1$ or $6n-1$." If he gets a proof at all, there is generally a lack of definite, systematic method of attacking it, and one is convinced that he is *not* being taught "to consider carefully given data and reason from this to accurate conclusions" to the extent that we might expect. I find that only a small per cent of those who come to us—a great many of whom are from the smaller high schools perhaps—are able to attack with any degree of elegance or satisfaction such theorems as the above.

Geometry can certainly be so taught as to secure to a very satisfactory degree the desired culture value spoken of above, but I fear that too often we are satisfied if the student of geometry can reproduce the book on the blackboard or on paper and possibly be able to justify each statement of the text by citing some previously studied proposition, axiom, or definition. The statement that one often hears in a geometry class that "I can't remember how it begins," "I forget the next step," or "I don't remember the proposition but I know how to prove it," leads me to believe that with far too many pupils and in too many class rooms the subject is more a drill in memory than an exercise in logic. Granting, however, that the student does see every step in the proof, and sees in the proof an example of logical deductive reasoning, the method of proof in our texts is necessarily synthetic, with no hint as to how the proof was discovered or what suggested the theorem; hence the study of the demonstrated theorems cannot of itself give the student the power to solve or prove the various propositions that will present themselves in other subjects. To get the greatest educational good from the subject the student must not be hurried through the course, learning simply the proofs of the text, but must supplement this by a great deal of original work in various demonstrations and solutions.

Happily the exercises (usually called originals in this country and riders in England) cannot be grouped into cases, and methods, rules, or principles given that enable us to solve all of each case as we used to do in our older arithmetics when we came to the subject of percentage, yet there are certain principles or methods of attack that make the study of an exercise systematic or scientific in the fullest measure, and unless the student is taught to study exercises in this systematic way—unless he is taught to study the exercises from the standpoint of analysis and thus discover the possible lines of procedure in attacking the demonstration—he is not gaining the power that is going to help him to study the larger problems of life. The student of geometry, when given an exercise, should no more fold his arms and try to recall "some proposition like it," or look through his or other texts for a proof than a student of botany or chemistry should determine a plant or find the ingredients of a compound by finding in his encyclopedia something that looks like it. He ought to have a definite line of procedure and be able when a proposition is proposed to do something if it is nothing but to waste paper, just as the student of chemistry would do something if nothing but have an explosion.

While but few rules can be laid down, these few give system to our work. Let us notice the general lines of procedure.

1. First, *assume that the theorem is true and draw an accurate figure*, and the accurately drawn figure will often suggest a proof; for example, certain triangles may appear to be congruent; if they are this will lead to some other relations that make the proof evident, hence we seek to prove these triangles congruent.

By assuming the theorem to be true is meant, that, if for example, certain lines or angles are to be proven equal they are to be drawn so; and drawing an accurate figure means not only that if lines are equal, parallel or perpendicular, they must be drawn so, but also that lines are *not* to be drawn equal, parallel or perpendicular unless they are given so. A triangle is not to be drawn with two sides equal unless the theorem calls for an isosceles triangle, nor a quadrilateral drawn with any two sides equal or parallel unless the exercise calls for a special quadrilateral of this kind.

An inaccurate figure may seem to show relations that do not exist, as in the examples given in "Ball's Mathematical Recreations" where all triangles are proven to be isosceles or a right angle equal to an obtuse.

2. After the figure has been drawn *get clearly in mind just what is given in the figure and just what is to be proven*, i. e., the *data* and the *conclusion.* It is also very important that *the student kuow the definition of all terms in the theorem*, and instead of the *hypothesis* and *conclusion* of the theorem it will be well to use Pascal's advice and "substitute the definition for the name of the thing defined" and thus get a *new hypothesis* and *a new conclusion.*

3. Next, *recall all the propositions that can have a bearing upon the exercise under consideration.* I believe that a large part of the difficulty that a beginning student has, comes from his not having clearly in mind all these fundamental facts that he needs. For example, if lines are to be proven equal, he must know all the propositions that refer to equal lines, such as congruent triangles, opposite sides of a parallelogram, etc. This in turn necessitates his knowing all the theorems concerning triangles, parallelograms, etc , and proving the triangles congruent will necessitate his proving angles equal, and this likewise requires the theorems concerning equal angles. Now, to get these fundamental facts fixed, I should require the student, at first, to recall with each exercise *all* the propositions that might possibly suggest a proof.

He is now ready after following each suggestion to its limit, to select those which it is *possible* to use as well as those which it is *best* to use. When he has done this for some time, until he has "at his tongue's end" all propositions and corollaries that he has proven, he sees in each of the terms involved in a theorem, not only the *one* definition of the term but *many*, and is able to select the particular ones that will lead to a proof. For example, he comes to think of parallel lines not only as those that do not meet but also as those that make with a transversal equal alternate interior angles, equal corresponding angles, or the two interior angles on the same side of the transversal supplementary. He thinks of a parallelogram not only as a quadrilateral whose opposite sides are parallel but also as a quadrilateral whose opposite sides are equal, two of whose sides are equal and parallel, whose diagonals bisect each other, etc. He is now in a fair way not only *to succceed*, but *to enjoy* the subject and get from it very helpful discipline.

4. But there is another very important feature that we have not mentioned, i. e., having recalled all propositions that can possibly relate to the thing to be proven, certain ones may be seen to apply, while again none of these may come directly under the figure as it is given: hence now, and not until now, is the student ready to draw, and draw intelligently, the auxiliary lines needed to make some of these theorems apply.

5. Now supposing that we have discovered theorems that may be made to apply, or by drawing auxiliary lines they may be made to do so; we reverse the steps of the analysis and give the regular synthetic proof.

6. After carefully analyzing the figure as suggested above, if no direct proof can readily be discovered, then *assume the theorem false* and by analysis prove that the assumption leads to an absurdity. This method is called the *indirect method* or *reductio ad absurdum.* As an example: *two*

triangles are congruent when the three sides ot the one are equal respectively to the three sides of the other.

In the other two cases of congruent triangles that the texts generally give before this one is taken up the triangles have angles in each equal, so that when certain sides are made to coincide it is known where the other sides *must* fall. In this case, however, since nothing is known of the angles, we do not know, when two equal sides are made to coincide, where the other sides are going to fall, hence we may assume that they do *not* coincide, but fall as in the figure below, and prove the assumption absurd.

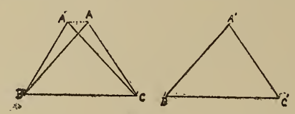


Fig. 1.

Proof. 1. Place △ A′B′C′ upon △ ABC so that B′C′ will coincide with BC and suppose that A′ does not fall upon A.
2. ∵ A′B′=AB and A′C′=AC, ∴ triangles A′BA and A′CA are isosceles.
3. ∴ the perpendicular bisector of A′ A will pass through B and C which is absurd.
4. ∴ the assumption that A′ does not fall upon A is absurd and the triangles must coincide throughout, and hence are congruent.

To illustrate the steps spoken of above in a single exercise, suppose we have the theorem that, *if the diagonals of a trapezoid are equal the trapezoid is isosceles.*

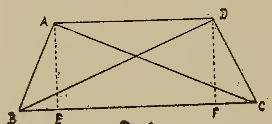


Fig. 2.

1. ∵ the trapezoid is to be proved isosceles it should be drawn so.
2. *Given* the trapezoid ABCD with AC=BD.
3. *To prove* that ABCD is isosceles. Now, use Pascal's advice and "substitute the definition in the place of the name of the thing defined" and say, *to prove* AB=DC.
4. *Analysis.* To prove lines equal requires,
   1. congruent triangles,
   2. parallelograms, etc.

   (a) To prove the triangles congruent requires that we have
   1. The three sides of one equal, respectively, to the three sides of the other,
   2. two angles and a side of one equal, respectively, to two angles and a side of the other, or
   3. an angle and two sides of one equal, respectively, to an angle and two sides of the other, (except in the ambiguous case).

   Again, to prove the angles equal requires,
   1. congruent triangles,
   2. vertical angles,
   3. parallel lines.

   (b) To prove a figure a parallelogram requires
   1. opposite sides parallel,
   2. a pair of opposite sides parallel and equal,
   3. opposite angles equal, etc.

Now, observing our figure, we see that none of these can be proven as the figure stands; we see therefore the need of other lines and seek to draw some line that will give a figure or figures that will enable us to use some

of the theorems recalled. Suppose our proof is to be that of congruent triangles. To get the necessary data in order to prove triangle ABC congruent to triangle BCD we must have in addition to what we already have, angle ACB equal to angle CBD; hence we form congruent triangles involving angles ACB and CBD. To do this we know that two right angles are congruent when the hypotenuse and a leg of one equals the hypotenuse and a leg of the other, and, that parallels intercepted between parallels are equal, and, that perpendiculars to the same line are parallel; hence we drop from A and D perpendiculars to BC and prove triangles AEC and BFD congruent. Now we have angle BCA equal to angle CBD and can prove triangles ABC and BCD congruent and hence the proposition.

Or the analysis might take the following form, called *successive substitution*, as given in *Beman & Smith.*

1. I can prove AB=DC if I can prove triangles BCD and ABC congruent.

2. I can prove these triangles congruent if I can prove angles CBD and ACB equal for BD=AC and BC is common to both.

3. But from the given figure I *can not* prove these angles equal; hence drawing auxiliary lines and proving these angles equal I can reverse the process and give the synthetic proof.

Summarizing the steps taken in dealing with theorems we may say:

1. Assume the theorem true and draw an accurate figure.

2. Get clearly in mind the hypothesis and the conclusion, being sure to understand the full meaning of all terms involved, substituting when necessary "the definition in place of the name of the thing defined."

3. Recall all theorems or definitions that refer to the point to be proven.

4. If none of these seem to apply to the figure as it stands, try to draw auxiliary lines that will involve the thing wanted and that will also give a figure to which some of the known theorems will apply.

5. If successful, then reverse the process and give the regular synthetic proof.

6. But if a *direct proof* is difficult to find, then *assume the theorem false* and show that the assumption leads to an absurdity. It might also be well to call attention to the fact that a *converse* proposition is generally more easily proven by this the *indirect method.*

The solution of a problem is approached in a little different manner from the demonstration of a theorem; and the investigation of problems, together with the discussion of the number of solutions in general, and of the relations existing in the data that give a definite number of solutions, and an indefinite number, and also that make the solution impossible, will supplement the discipline obtained from the demonstrations of theorems and give that desired discipline that will better prepare one to solve the various problems that may arise in other subjects. Edwards in his geometry says: "The manner of approaching the solution of any problem is the same in all subjects, i. e., we are to approach it through analysis."

1. In seeking a key to the solution of a geometric problem, in order to aid the analysis, it is generally best to assume the solution performed and from the elements of the figure, recall some known relations that have already been proven. Having discovered enough of these relations make the construction depend upon them.

2. In beginning the study of these problems already solved in the

texts, the student should be made to know at once that *all* solutions *must* depend upon some known theorem or theorems which should be recalled. I should have the student recall other theorems, if such exist, that might suggest a solution other than the one given in the text. The student must see not only that to solve a problem he must be able to recall some known proposition that makes the construction evident, but he must see also that all problems must be reduced to one or both of the fundamental problems, *to draw a straight line between two points* or to *describe a circle of a given radius about a given point as center*, and also that the required points are found by the intersection of two lines, straight or curved; hence that almost every solution must depend upon *the intersection of certain loci.*

3. The simplest and most common problems that we have in elementary geometry are those in which the analysis leads to the discovery that the points wanted are on certain loci, hence at their intersection. This method is called the *intersection of loci.* As an example, *to describe a circle of given radius to pass through a given point and cut off equal segments from two parallel lines.* Now this depends upon finding the center of the circle. The analysis leads to the discovery that the center of this required circle is the intersection of the locus of points equidistant from two parallel lines, and of the locus of all points equidistant from a given point, which is a straight line and a circumference. Since a straight line will cut a circumference in two points two solutions in general are possible.

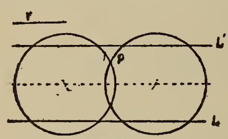


Fig. 3.

The method of *intersection of loci* is used to such an extent in constructive geometry that the student ought to be made familiar with the most common theorems of loci, and have them fresh in mind when taking up this subject.

While I am aware that most students go through some sort of analysis without perhaps even being conscious of it, I am sure that the most good will come from the course if the student is made to realize that there is a systematic analysis involved in every discovery of a solution, and if he is required to begin all solutions either written or oral by giving the analysis that led him to see the solution.

4. It will often occur that the analysis of the figure will not reveal any known relations that will give the means of determining the required points without drawing auxiliary lines that will transform the given figure into a a new one which will involve certain elements of the old, just as was done in the case of theorems. This might be called the *method of transformation.* Just as the most difficult theorems were those that had to be transformed by auxiliary lines, so will this class of problems give the most trouble, and the skill in being able to see the needed auxiliary lines will largely determine a student's success with exercises of this sort.

As an example, suppose we are *to construct a triangle having given two sides and the median to the third.* Now the figure with the median drawn seems to give no way of finding the two remaining vertices when one is fixed but if the median be continued its own length and the extremity joined to the extremities of the base the problem is seen to reduce itself to constructing a triangle when three sides are known.

5. The auxiliary lines needed to transform the figure into a new one, however, are usually drawn parallel to lines in the original figure, i. e., certain lines are considered to be moved parallel to themselves, called

translated, thus giving a new figure which involves elements of the old and which makes the solution evident. Such a method of solution is called the *method of parallel translation*. As an example, *suppose we are to construct a trapezoid having given the diagonals, the angle made by them, and the sum of two adjacent sides.* Assuming the problem solved and the trapezoid to be ABCD, we can get no relations from the figure as it stands to tell us where to intersect the diagonals or where to draw a side if a diagonal is fixed; hence we must transform the figure by auxiliary lines. Drawing through A, AB′ parallel and equal to DB, and through B′, B′C′ parallel and equal to AC, it can be proven that the side AB of the trapezoid coincides with the diagonal of the parallelogram thus formed, and the solution becomes evident.

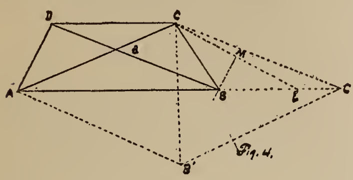


Fig. 4.

6. While nearly all problems are finally solved by the first method given, i. e., by the method of *intersection of loci*, still it often occurs that before one finds the required loci a difficult analysis has to be performed and then the method of attack is called simply the *method of analysis*, which in reality is the fundamental method involved in the search for a key to the solution of any problem. The problem *to draw a circle whose circumference shall pass through two given points and also be tangent to a given straight line*, is an example of this kind. Suppose A and B to be the given points and L the given line. Now if A and B be joined and this line extended to meet L in O, it is known that the square of the segment on L from O to the point of tangency of the required circle is equal the product of the segments OA and OB; but it is known that this is also true of the length of the tangent from O to any circle through A and B, hence one has simply to describe any circle through A and B and draw from O a tangent OD to this circle, and then OP on L and equal to OD will give the point of tangency P on the given line and the center of the required circle is easily determined.

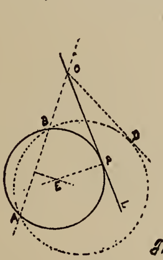


Fig. 5.

Since no two problems are solved alike the power to successfully attack an exercise comes from a great deal of practice, coupled with a close observation of the method by which each exercise was studied, rather than from the study of the few methods given above, but I believe that a student has had his attention called to these general methods he will become much stronger and much more interested in his work and gain to a larger degree the strength to handle the problems of any other department.

Simplicity and Exactness in Geometrical Constructions

EDWARD B. ESCOTT, INSTRUCTOR IN MATHEMATICS, UNIVERSITY OF MICHIGAN

It seems quite remarkable that the systematic study of the questions of simplicity and exactness in problems of geometrical construction has been undertaken only within the last fourteen years. In 1888 M. Emile

Lemoine presented to the meeting of the French Association for the Advancement of Science some general considerations on simplicity in geometrical constructions, and since then he has systematized and completed the theory.

A general exposition of the subject may be found in a book which has just appeared:—

E. LEMOINE. *Geometrographie ou art des Constructions geometriques*, published by C. Naud, Paris.

An article by M. LEMOINE, "*Principles de la Geometrografie ou art des constructions geometriques*, appeared in GRUNERT'S *Archiv der Mathematik und Physik*, in 1901, and a slight sketch of the method in the *Bulletin of the American Mathematical Society*, January, 1902, p. 137. There is a note on the subject in the last edition of *Rouche et de Comberousse's Traite de Geometrie Elementaire.*

By the "geometrographic" construction of a problem, is meant that construction of which the coefficient of simplicity, which will be defined later, is the smallest. It ceases to be geometrographic if a construction is discovered which is still simpler, and this becomes then the geometrographic construction. In order to render the constructions comparable we shall suppose—without particular notice to the contrary—that we may use only a single compass; that there is on the drawing at the beginning only the given magnitudes; that we do not execute on the given magnitudes the definitive drawing unless it is specified by the question:

Geometrography has four aims:

1. It gives for a construction a symbol which is a kind of measure of its simplicity and of its exactness.

2. It leads to processes which enable us to effect, in the simplest manner possible, a construction deduced from a geometric solution.

3. It studies and discusses a construction of which the principle is indicated, to substitute for it in some cases a construction which may differ entirely from the first one.

4. It permits us to compare all the constructions which are known of the same problem and to choose the geometrographic construction.

NOTATION

A (r) or A (MN) denotes a circumference of center A and radius r or MN.

We assume that all lines drawn are indefinite in extent.

To place the edge of the rule on a point is called the operation R_1 or Op. (R_1). Then to place the edge of the rule on two given points is Op. $(2R_1)$.

To draw a line along the edge of the rule is Op. (R_2).

To put either point of the compass on a given point is Op. (C_1); then to take between the arms of the compass the distance between two points is Op. $(2C_1)$. To put a point of the compass on an undetermined point of a line which is drawn is Op. (C_2).

To draw a circle is Op. (C_3).

Every construction may then be expressed finally by the symbol Op. $(l_1 R_1 + l_2 R_2 + m_1 C_1 + m_2 C_2 + m_3 C_3)$, l_1, l_2, m_1, m_2, m_3, being integers. $l_1 + l_2 + m_1 + m_2 + m_3$ will be called the *coefficient of simplicity;* or the *simplicity;* $l_1 + m_1 + m_2$, which corresponds to the operations of preparation, will be called the *coefficient of exactness* or the *exactness;* l_2 and m_3 are

respectively the number of straight lines and the number of circles drawn.

FUNDAMENTAL CONSTRUCTIONS

To draw a line,

1. at will, Op. (R_2).
2. through a given point, Op. (R_1+R_2).
3. through two given points, (Op. ($2R_1+R_2$).

To take a given length in the compass, Op. ($2C_1$).

To draw a circle,

1. at will, Op. (C_3).
2. with an indefinite radius but with a given center, Op. (C_1+C_3),
3. with a given center and which passes through a given point, Op. ($2C_1+C_3$)
4. with an indefinite center but with a given radius, Op. ($2C_1+C_3$).
5. with the radius a given length and the center a fixed point, Op. ($3C_1+C_3$)

To lay off on a line which is drawn a length from an undetermined point of this line, or starting from a point on this line, the length comprised between the arms of the compass. Op. (C_2+C_3), or Op. (C_1+C_3).

ELEMENTARY CLASSICAL PROBLEMS

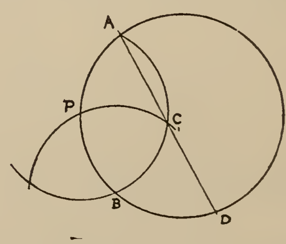
I. To construct a right angle, or to draw two perpendicular lines.

(a) Draw a circle (C_3); a line cutting the circle in A and B (R_2). Connect A and the center O of the circle ($2R_1+R_2$). OA cuts the circle again in C. Draw CB ($2R_1+R_2$); the angle CBA is a right angle. Op. ($4R_1+3R_2+C_3$). Simplicity 8. Exactness 4. 3 lines, 1 circle.

(b) Draw any two circles O(r), O′(r), intersecting in A and B ($2C_3$). Draw AB and OO′ ($4R_1+2R_2$). Op. ($4R_1+2R_2+2C_3$). S. 8; E. 4. 2 lines, 2 circles.

(c) Draw a line (R_2); with any two points of this line as centers draw circles ($2C_2+2C_3$) intersecting in A and B; draw AB ($2R_1+R_2$) Op. ($2R_1+2R_2+2C_2+2C_3$). S. 8; E. 4. 2 lines, 2 circles.

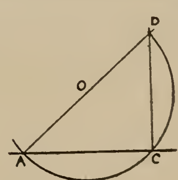
II. To find the length of the radius of a circle of which the center is not given.



P being an arbitrary point on the circle, draw any circle P(r), (C_2+C_3) which cuts the given circle in A and B. Draw B(r) (C_1+C_3) which cuts P(r) in two points. Join either one of them, say C, to A ($2R_1+R_2$) AC cuts the given circle in D. DC is the length of the radius.

Op. ($2R_1+R_2+C_1+C_2+2C_3$) S. 7; E. 4. 1 line, 2 circles.

III. At a point C on a given line AB, to erect a perpendicular to this line.

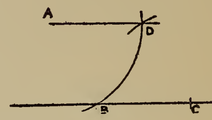


(a) The classical construction has for its symbol Op. ($2R_1+R_2+3C_1+3C_3$). S. 9; E. 5. 1 line, 3 circles.

(b) Geometrographic construction. Place one point of the compass in an arbitrary point O, place the other on C (C_1), draw O (OC) (C_3) which cuts CA in A. Draw AO ($2R_1+R_2$) cutting O (OC) in D; draw DC, ($2R_1+R_2$). Op. ($4R_1+2R_2+C_1+C_3$) S. 8; E. 5. 2 lines, 1 circle.

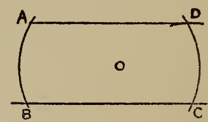
IV. Through a point A to draw a parallel to the line BC. (a) and (b) the two constructions commonly given have the following symbols, Op. $(2R_1+R_2+5C_1+3C_3)$. S. 11; E. 7. 1 line, 3 circles.

Op. $(3R_1+2R_2+5C_1+3C_3)$. S. 13; E. 8. 2 lines, 3 circles.



(c) Draw A (r) giving B, then B (r) giving C $(2C_1+2C_3)$. Draw C (r) which cuts A (r) in D (C_1+C_3). Draw AD $(2R_1+R_2)$.

Op. $(2R_1+R_2+3C_1+3C_3)$. S. 9: E. 5. 1 line, 3 circles.

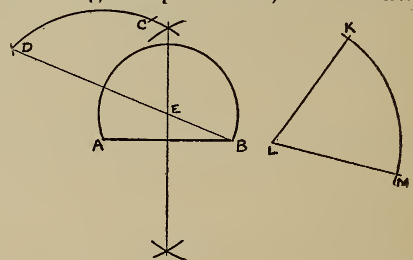


(d) Draw a circle O (OA) (C_1+C_3) which gives B and C. Take AB in the compass $(2C_1)$, draw C (AB) (C_1+C_3) which places D on O (OA) on the same side of BC as A. Draw AD $(2R_1+R_2)$. Op. $(2R_1+R_2+4C_1+2C_3)$. S. 9; E. 6. 1 line, 2 circles.

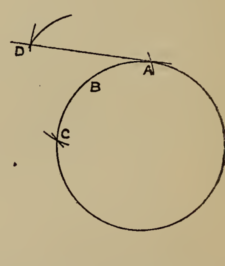
V. On a given line as chord, to describe a segment of a circle containing a given angle LMN.

(a) Classical construction. Draw BD making with AB an angle equal to LMN; draw the perpendicular bisector of AB and the perpendicular at B to BD, these two perpendiculars intersecting in O; draw O (OA). Op. $(6R_1+3R_2+11C_1+8C_3)$. S. 28; E. 17. 3 lines, 8 circles. In conducting the operations with economy we may reduce the symbol by (C_1+C_3).

(b) Geometrographic construction. Draw the circles A (AB), B (AB) $(3C_1+2C_3)$, then L (AB) (C_1+C_3) which gives points K, M. Draw B (KM) cutting A (AB) in C, and C (KM) cutting same circle in D, $(4C_1+2C_3)$. Draw the perpendicular bisector of AB $(2R_1+R_2)$, and BD $(2R_1+R_2)$ intersecting in E; finally draw E (EA) $(2C_1+C_3)$ which gives the segment required. Op. $(4R_1+2R_2+10C_1+6C_3)$. S. 22. E. 14. 2 lines, 6 circles.



VI. To draw a tangent to a circle of center O, at a point A on the circle.



(a) The common construction is to erect a perpendicular to the radius at its extremity. Op. $(6R_1+3R_2+C_1+C_3)$. S. 11; E. 7. 3 lines, 1 circle.

(b) Geometrographic construction. B being any point of the given circle, draw B(BA) $(2C_1+C_3)$ which cuts it again in C; draw A (AC) $(2C_1+C_3)$ which cuts B (BA) in D. Draw DA the required tangent $(2R_1+R_2)$.

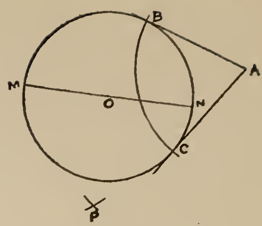
Op. $(2R_1+R_2+4C_1+2C_3)$. S. 9; E. 6. 1 line, 2 circles.

VII. From a point A outside a circle of center O, to draw a tangent to the circle.

(a) Classical construction. Draw OA; describe the circumference which has OA for diameter and cuts the circumference in B and C, the

points of tangency. Draw AB and AC. Op. $(8R_1+4R_2+4C_1+3C_3)$. S. 19; E. 12. 4 lines, 3 circles.

(b) Geometrographic construction. Draw any diameter MN (R_1+R_2); draw M (OA), N(OA) $(4C_1+2C_3)$ intersecting in P. Draw A (OP) $(3C_1+C_3)$ which cuts the given circle in B and C, the points of tangency. Draw the tangents AB and AC. $(4R_1+2R_2)$. Op. $(5R_1+3R_2+7C_1+3C_3)$. S. 18; E. 12. 3 lines, 3 circles.

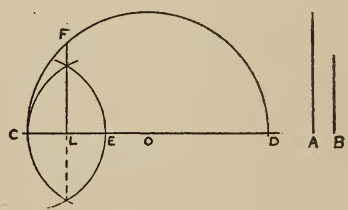


VIII. To construct the mean proportional X between two given lines A and B. $X^2=A\cdot B$. Let A>B.

(a) (b) and (c) the three constructions commonly given; the first two are based on the properties of the segments of the hypotenuse of a right triangle made by the perpendicular from the vertex of the right angle, and the third is based on the property of the tangent to a circle and the segments of the secant drawn through the same external point as the tangent. They give for simplicity and exactness,—

(a) S. 22; E. 14; (b) S. 28; E. 17; (c) S. 30; E.19.

(d) Geometrographic construction. Draw any line (R_2) and with any point of the line O as center, draw O(A), $(2C_1+C_2+C_3)$ which cuts the line in C and D. Draw C (B) $(3C_1+C_3)$ which places E between C and D; draw E (B), (C_1+C_3) and through the intersections of these two circles draw the perpendicular bisector of CE cutting O (A) in F. CF is the mean proportional. Op. $(2R_1+2R_2+6C_1+C_2+3C_3)$ S. 14; E. 9. 2 lines, 3 circles.



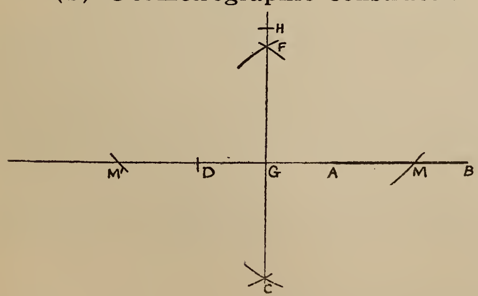
We can prove this by noticing that in the right triangle CFD, $\overline{CF}^2=CL\cdot CD=\frac{B}{2}.2A=A\ B.$

IX. To divide a line AB in extreme and mean ratio.

(a) Classical construction. In making this construction as it is ordinarily done, we have Op. $(6R_1+3R_2+11C_1+9C_3)$. S. 29; E. 17. 3 lines, 9 circles. By geometrographic principles it may be reduced to Op. $(4R_1+2R_2+10C_1+8C_3)$. S. 24; E. 14. 2 lines, 8 circles.

There are a great number of constructions more simple than the classical construction, among them several geometrographic constructions. The following is one of them.

(b) Geometrographic construction. Draw A (AB) $(2C_1+C_3)$, which cuts AB in D; draw D (AB) (C_1+C_3) cutting the first circle in F and C. Draw FC cutting AB in G. Draw G (AB) cutting FC in H. While the point of the compass is at G, take the length GB in the compass (C_1), then draw H (GB) (C_1+C_3) cutting AB in M and M^1. M is the point of internal division and M^1 the point of external division. Op. $(2R_1+R_2+$



$6C_1+4C_3$). S. 13; E. 8. 1 line, 4 circles. The simplification in this case is from 29 to 13.

That which precedes is sufficient to show the application of Geometrography. It is remarkable that it has been possible to simplify all the fundamental constructions, sometimes to a very great extent, as in the construction of a mean proportional from 28 to 14, and in the division of a line in extreme and mean ratio from 29 to 13.

The author, M. Lemoine, has applied geometrographic methods to a considerable number of other problems, and has also modified these constructions by allowing other instruments to be used, in particular the square or right triangle used by draughtsmen.

BIOLOGICAL SECTION

Conference of the Biological Section

Two sessions were held, Friday afternoon and Saturday afternoon, March 28 and 29, the latter being a joint session with the Michigan Academy of Science. Both sessions were well attended.

After calling the meeting to order and making announcements, the chairman, Mr. L. Murbach, made some remarks on the proposed amalgamation of the biological section with the Michigan Academy of Science. He said the biological section would better not surrender its identity by fusion with the Michigan Academy of Science, but that the Michigan Academy of Science might form a science-teaching section which the members of the biological section could join, leaving them the opportunity to hold their own conference at any time when the Michigan Academy of Science meets at a different time or place from the Schoolmasters' Club. He pointed out the advantages of the union as, membership in the larger body, opportunity to hear purely scientific papers, and the right to the publications of the proceedings. Pending the action of the Michigan Academy of Science, the Conference proceeded with its program, electing Dr. F. C. Newcombe, chairman, and Miss Genevieve Derby, secretary.

Papers were presented as follows:

THE RELATION OF NATURE STUDY TO HIGH SCHOOL BIOLOGY

RAY A. RANDALL, ASSISTANT PRINCIPAL, GOSHEN (IND.) HIGH SCHOOL

Never before has the subject of science occupied the prominent place in which it stands now. Never has the progress of civilization been so rapid as the last century, during which time science has done so much for the world. Science is the mother of civilization. This advancement was brought about by the mental operations of observation, experiment, classification, deduction, and generalization.

Today all scientific training, all scientific knowledge must come through these primary conceptions and today these primary conceptions

must come through nature's door as in the past. For the child's nature, dependent upon his inherited impulses, necessitates the exercises of his powers through experiences similar to those which took part in the physical and mental development of his ancestors. The lifeless forms of Latin and Greek are no longer in the path of advancement. We now think in our own language, but the present century has yet to blot out the word or the form idea of the old regime. We think the child has the idea when he has only the form in which it is expressed. The present day idea of teaching the child new words by associating the word with the object I believe to be radically wrong in that it makes nature subjective, not objective. The object in the child's hand becomes a part of his experience and that experience expressed will bring the word desired.

Nature study furnishes a basis of reasoning, i. e.: from particular to general, which applied to other studies makes real their notions. It puts the child in the right attitude for work, makes him independent in thought and action, and by its reactive influence moulds the character.

Upon recognizing the aim and importance of nature study in the grades we next turn our attention to the presentation of the subject, to the basis for work and the relation of the work to High School Biology. Many attempts to introduce nature study in the grades have failed, and I dare say it is due to a great extent to the method in vogue of leaving the science work to the grade teacher. To teach nature study in the right way a Col. Parker is needed, a person who can lead others to observe and experiment. Time and a great deal of it is needed. Time to locate the proper field of study, time to take the children to the fields, time to prepare and perform experiments, time to look over note-books with the individual. Systematic work is needed, not a heap of experiment without a definite aim in view. Material both for experiment and observation is need d and should be of the proper kind and plenty of it. In most Graded Schools at the present time nature work is taught by the teachers of the respective grades and in most cases, not knowing the subject they are instructed in the work by the superintendent or science teacher. Due to the nature of the case they cannot fulfill the requirement of a nature study teacher. A specialist born a naturalist would satisfy the condition, and since the importance of a right relation of the child to nature cannot be measured in dollars and cents, an argument against the expense due to the employing a special instructor for the town, has no basis. Again if we recognize nature study as being on a par with reading, language, history, etc., it demands a place in the curriculum and should be presented by a teacher whose acquaintance with the subject is as thorough as with other subjects. One instructor could handle from three to five grades giving six hours a week to a grade by devoting three periods of two hours each to each grade, with satisfaction.

In Biology which furnishes a large share of topics for nature work the natural whole may be the single animal or plant or several living objects taken together to form a society for a definite aim or purpose. Such units or wholes as above mentioned form a natural basis for deductive reasoning, comparisons and generalizations. The course of reasoning should be, in general, first, observation of life in the single thing and repeated recognition of the different fundamental laws: second, application of the laws to unfamiliar objects and life societies.

In the selection of topics strict scientific order should not control.

Factors like material of home environment, seasons of the year, corrrelation with subjects like history, literature, and geography, and ability of the child should figure to a great extent in the sequential arrangement of material. The arrangement of material for study should be such that the pupils in the lower grades could do mainly observational and creative work, gathering data and motives for the generalizing and interpreting which should become more and more prominent and which should gradually increase in difficulty during each successive grade. Repetition should be avoided as much as possible by assigning concrete material for each grade. The provision of material should be such as to insure the largest return to the children. For our work we may rely upon material provided spontaneously by nature or upon the creative effort of the child in planting the seed and caring for the plant or in protecting and caring for animal life. In the case of spontaneous provision, the child under proper direction may bring material to the class-room or he may study the object in its natural habitat.

As a preparation for High School Biology the pupil should have a love for and a sympathy with nature, a desire to investigate and the power to generalize and deduce, correct habits, the where, when, and how of finding material, a scientific spirit, proper nomenclature and facts. Of these the fundamental consideration upon which all the others depend is love of nature which constitutes a means to an end and also an end in itself. Nature study does not aim to make specialists but to educate, to make life happiness in the best sense of the term. Hence the necessity of a sympathetic relation, for to be in touch with nature is to live to enjoy happiness. A desire to investigate would follow in most cases from a sympathetic relation toward nature. The investigation under proper guidance would suggest the fundamental laws already alluded to.

Too much cannot be said as to the formation of habits. By eight or nine the brain reaches the adult size, the fundamental lines are formed and habits contracted become established to show in after years. If habits of indolence, carelessness, disrespect of surroundings have been allowed to develop the reformation in after years will be difficult and perhaps never wholly accomplished. When ready for High School Biology the pupil should be acquainted with nature to the extent that he would know where to get it, and how to handle it after having it in his possession. He should know the parts and their relation in a general way to each other. The inability of pupils to handle material, the timidity in the presence of material is the time wasting element in High School work. Artificial surroundings have made the natural foreign to the senses. The material to appeal to the child must be seen in its natural habitat. The struggle for existence and the protective measures for that struggle appeal to the emotive and intellectual side and stimulate to action.

In treating the subject in a scientific spirit, facts in sufficient number should be in evidence before a conclusion is drawn. Plants and animals should not be presonified or endowed outright with motives.

The use of technical terms has been a subject of much discussion. In most text-books on Biology the technical terms used are thoroughly incorporated in the language of the subject and contain no objectionable terms. Desirable technical terms are acquired when learning the thing to which they belong with as much ease as a foreign language, when a part or organ is discovered a name becomes a necessity and used as a means to communicate and point out to others the name is easily acquired.

But with the many good outlines in the field with a definite understanding as to what should be the preparation for High School Biology we are still confronted with the problem of arrangement of subject matter to bring about the desired relationship between nature study and High School Biology due perhaps to the existing experimental stage of High school Biology and the failure to introduce nature study in the grades. In most cases High School Biology starts with the High School and extends through a period of one semester or two semesters at the most. The pupil appears for the first time in the class-room without any idea of what is expected of him. His habits as to manner of study are fixed to a great degree. He is not in a position to observe and experiment. Ask him a question concerning a certain twig or branch and he will peruse his text for an answer. He will jump at conclusions without reason. There is in the young mind a habit of verbal memorizing, the placing of general notions due to the text-book work. First, then, there must be a reconstruction in the habits of thought which have been successful. At best you have a student beginning nature study. Under such conditions I believe the grade work should be presented in an abbreviated form and if possible bring about a right relationship between the child and nature and place him on a footing for scientific work. What the colleges desire is the student well grounded in fundamental principles rather than one who has a smattering of facts of no real basis for observation and reasoning.

In opening the discussion of the paper, Miss Gertrude Gillmore, of the Washington Normal School, of Detroit, contended that, while especially trained science teachers are necessary to organize and conduct the work, yet, the grade teacher is better fitted to teach the child directly as, she is more familiar with his environment and capability. In answer to the suggestion that the grade teacher is generally ignorant of what to teach and how to teach it, Miss Gillmore responded that she is to take up each subject a month beforehand and do a little at a time under the guidance of the special teacher, until she is prepared. Miss Gillmore then explained her method of conducting such work. Both speakers advocated biological material for nature work rather than minerals or physical phenomena, that are sometimes introduced.

THE RELATION OF LABORATORY, FIELD, AND RECITATION WORK IN BIOLOGY

MISS FRANCES L. STEARNS, ADRIAN, MICH

In Michigan it is no longer necessary to discuss the introduction of the laboratory method in biological sciences. It has proved itself the natural and substantial basis of the high school courses in these subjects and the well-equipped laboratory, if not a part of the school, is recognized as a legitimate demand. We claim for this work that it trains the pupil in habits of observation, accurate recording of observation,—thus developing good mental habits—clear reasoning, and well-balanced judgments. Therefore it better equips him not only to meet and settle problems of science, but to act wisely in the solution of all problems which life brings to him.

It has come to be recognized that the morphological and the physiological work which is possible in the laboratory fails in two directions. First, it fails to give the pupils a first-hand knowledge of plants and animals in their homes, an acquaintance with the life with them in the out-of-doors. A second phase of biological work which cannot be covered in the laboratory is the study of the relationships which exist between living things, their neighbors, and their environment,—the ecological aspect of biology. This department of science is most fascinating for the mature student for it gives him valuable information for the establishment of laws which govern life activities, and to the unscientific, even, the plants and animals become individuals, living individuals with interesting and original ways of doing things.

Field work as a method of instruction for high school pupils is as yet in its experimental stages. Those of us who have been in touch with the spirit of scientific work in this state must teach ecology whether we do so consciously or not for ecology is fundamentally a way of looking at things, the method of approach. It is the question "why" not "what." But the only logical order is *what*, then *why*. Bring these as close together as possible, but we must always precede the explanation,—the theory, by the information, the facts. Give the high school pupil both if you can, but I hold that we should spare no effort to give the boy the first key to the mysteries of life which surrounded him—the what.

There are some of us who still see value in the much ridiculed herbarium and natural-history collection. Field-work is not this but it systematizes and organizes the methods and efforts called out by this kind of work.

It has been said that the kindergarten is the greatest institution ever devised for the education of the parents. I think field work is a close second. The unfamiliarity of methods and facts makes many parents skeptical; they do not see what it is all about. I once heard a man say he was completely demoralized when he went to the woods, and I think he expressed the feeling of not a few pupils. Is not the explanation largely their unfamiliarity with the surroundings? This man's ideals of life—and they were high—had not come to him through the channels of the senses but through written words. I think one remedy for this condition of mind is early work in nature study. When the trees, the flowers, the animals have gained an individuality for themselves, the center of interest will be transferred to them and the child will be left in the proper condition for healthy work,—complete consciousness of self.

The scheme of competitive gardening seems a most sane method of laying foundation-work for science and is certainly meeting with most gratifying results.

The poor grade teacher, ridden to death with fads, will probably groan to see another and will resent the suggestion that the herbarium and natural history collection belongs here. But when the instinct for ownership is strong, the body needing training, and there are endless animal spirits to be worked off, is not this a good time to answer the "What is it?" for natural science?

Until these preparations have been made, what can we do? Familiarize as much as possible by talks preceding the trip, by short excursions near home, by carefully prepared questions distributed beforehand, and ask the question "Why?"

Another word about the recitation. I have left it until the last because it should come last. It should not be the place to give information but one for the pupil to have opportunity of expressing what he has learned, for gathering up facts, and deducing laws, for classifying, and fixing the pupils ideas.

The laboratory, and recitation work, all make legitimate demands on the high school course, but the teacher, the laboratory equipment, the location of the school, arrangement of programme are all factors which must be known before the problem can be solved.

Following this, *Professor Chas. A. Davis, of the University of Michigan*, on the "POSSIBILITIES OF FIELD WORK," emphasized points made in the preceding paper, and contrasted past with present methods. He said all the difficulties of field work are no more fundamental or valid than the objections formerly urged against the laboratory method. The possibilities of field work are great when (1) teachers will prepare for it as they do for other kinds of work, by constant study of the region in which they teach; (2) the size of class sections taken to the field is small, not exceeding twenty; (3) the work is carefully planned and pupils are properly guided and watched; (4) the classes are questioned as to what they see, and are not simply told what the teacher sees; (5) when the special object of the exercise is coördinated with other related topics by questions and suggestions. Possible lines of work in botany, zoölogy, geology, and physiography were then suggested, and teachers who have to do this sort of work with their classes and hope to be successful were urged to take up field work for themselves.

In the discussion following it was evident that the majority of teachers did field work only as a side issue, and that this subject should be further developed; that twenty-five was as large a number as could be profitably taken at one time; that in cities much can be done in the parks; with large numbers it is better to have written directions or questions; that a successful way of doing field work is to take only the most interested students.

Acting on a suggestion previously sent in by Professor S. O. Mast, that it would be desirable to have a set of experiments in Plant Physiology, the chairman appointed a committee to formulate a set of such experiments, with suitable apparatus for a half or a whole year's high school course.

A paper from Miss Grace Ellis, of Grand Rapids, on "PHYSIOLOGY AS A SCIENCE STUDY IN THE HIGH SCHOOLS," made the following points: The optimum and logical preparation for physiology would be that botany, zoölogy, chemistry and physics should precede it. In case it cannot be preceded by these, simple experiments in chemistry and physics must be made in order to make the subjects in physiology comprehensible. Here is the starting point. In the laboratory, guided only by a sheet of directions and tested by questions, the learner finds out something of the composition of his own body. This introductory work may be followed by a set of simple experiments on acids and alkalies, then by tests for respiration, excretion, in order, ending with the study of the nerves and ganglia, especially as seen in the frog. All these are studied experimentally first. Physiology, hygiene, and sanitation should be the interpretation of the simple physiology of our course of study. It is desirable that there be a widespread understanding of the nature of contagious diseases in order that the action of medical boards and boards of health may have a meaning in the minds of

the public at large. The creation of such an understanding seems to me an important duty of the public schools.

Mr. Raymond Pearl, of the University of Michigan, then read a paper on "PRACTICAL PHYSIOLOGY IN THE HIGH SCHOOL." He said in substance: Physiology, as taught in the average high school, is open to criticism from three general standpoints. These are: (1) high school physiology comprises for the most part something other than true physiology; (2) its purpose is too largely one of attempting to impart a concrete knowledge of the human body, without regard to general training; (3) the method of presentation to the student is faulty for two reasons: First, in that the most complex rather than the simple is taken as the starting point; and second, in that the subject is presented dogmatically, i. e., something finally known.

The most important things which will contribute towards the elevation of high-school physiology to the level where it ought to stand are: (1) the use of a rational laboratory method for the purpose of developing the student's general mental powers; (2) the presentation of the subject as a living affair to be investigated, not something dead to be memorized; (3) the substitution of the standpoint of "general physiology" for that of "organ physiology;" (4) the presentation of something of the historical development of the science as a practical means of holding the student's attention.

The program closed with a paper by *Dr. H. S. Jennings, of the University of Michigan*, on "SOME BIOLOGICAL PROBLEMS."*

At the close a resolution was offered that, as physiology in its broader sense is one of the biological studies and may, if properly taught, be made of equal value with any other, it should justly be recognized by university authorities, and that such recognition would promote its better teaching.

Second Conference of the Biological Section

JOINT SESSION WITH THE MICHIGAN ACADEMY OF SCIENCE

In a paper on "ORIGINAL WORK FOR THE HIGH SCHOOL TEACHER," *Mr. E. L. Moseley*, who has done so much for science in the Sandusky High School, gave a most striking illustration, a concrete example, of a piece of original work he had done in locating buried valleys of streams running into Sandusky Bay. His boys accompanied him at one time or another, and one of them helped in the discovery of an old creek bottom that explained one of the problems that was at the time puzzling them. It was shown that such work may furnish a valuable basis for future engineering operations. . . . The conclusion reached was that the valley now filled with mud and covered with water must have existed before the waters of Lake Erie had been raised so far westward, and that if this rise continued, ultimately Sandusky, Toledo, and then Chicago, would be submerged. He then said: "I have been asked to answer certain questions pertaining to original work for the high school teacher. First: how to get a subject? Become a member of the Academy of Science and attend its meetings. You will find out in that way what other investigators are doing and learn of a number of things that need further study. When possible, attend also the meetings of the

* The manuscript for this paper was not obtainable.

American Association for the Advancement of Science. At Pittsburg beginning June 28, will be the last of the summer meetings. After 1902, the annual meetings are to be held convocation week and the first will be in Washington about Jan 1, 1903.

If you can induce scientific men to visit you, you may get valuable hints as to problems for the solution of which your locality affords peculiar advantages. By a few minutes' conversation you may learn things you were anxious to know and could not find out by hours of reading.

A desire to know is the best stimulus to investigation. Oftentimes the result may not be worth publishing, but it is a satisfaction to have learned something about the subject by your own researches. Such knowledge means more to you than what some one else may have found out about the subject, just as the pupil gets benefit from performing experiments for himself instead of merely seeing them performed.

The second question is: how to find time for original work? First, by giving up other things. Miss Cole, who has given us the admirable Flora, of Grand Rapids, Mich., and vicinity, for years devoted to the work her spare time on school days and Saturdays, and the greater part of summer vacations, when she would find board for a week or two at some farm house in a good location and then go to another district until she had made a thorough study of the flora of sixteen townships. The enthusiast in any subject is willing to sacrifice many other things in the pursuit of it.

Many a teacher has the talent to illumine some scientific subject, if it were not overshadowed by the desire to make money. Many whose aptitude for research would lead to valuable discoveries are tempted by the prospect of better pay to seek and ultimately to find a position whose administrative work is too onerous to allow any time for original research. Others devote what spare time can be spared from school work to hearing private pupils, or to some business that can be attended to on Saturdays or after school hours.

Few teachers of science can have any reasonable expectation of getting rich as a result of their discoveries, and if they are not contented to live in a humble way but consider riches essential to their happiness, they are not likely to use any portion ot their slender income for original research or devote to it any time which they might utilize for remunerative work.

The investigator who is devoted to his work may find it necessary frequently to curtail the time he would like to devote to literature and newspapers, to learn ths news of current events mostly from weekly papers or from magazines whose news is more important and reliable than that of the daily papers, and to have some one who has time to read the latter tell him the things in which he is likely to be most interested.

More important than all other means of securing time for original work is the maintenance of health, for its impairment means not only the shortening of life but greatly diminished capacity for labor.

Besides insisting on good ventilation the teacher should be outside at least one hour out of every twenty-four. Living at some distance from the schoolhouse and not using a street car may insure this. The teacher of biology can do much to preserve his health if he goes after school to collect material for his class or to enjoy and study nature in the fields and woods and much for the health and pleasure of his pupils if he takes them along.

Rest after meals and regular and sufficient sleep may prevent one from accomplishing so much in a certain week or term, but will enable him to accomplish more in a lifetime. Likewise mild stimulants, to say nothing of strong ones, diminish in the long run one's capacity for work. Short-sighted is the author of a physiology who commends coffee because it destroys the sense of fatigue. Ambitious persons are prone enough to work on, after brain and nerves and eyes have been taxed until further strain will prevent them fully recovering their original vigor. They need no artificial stimulant to spur these organs to herculean efforts or make them obiivious to the warning of the sense that tells them it is time to rest. With many teachers doubtless the habit of working late at night is contracted while at college. In the literary department working late was formerly not necessary for most students, and it is not now, though many seem to assume that it is. Young ladies who stand high in their classes and yet always retire early, inform me that those who do differently fritter away much of their time during the day, depending on the night time for study.

Frequent moving from place to place may facilitate the study of certain subjects, but for others it must be a serious hindrance. The investigator should have books and notes and specimens classified and arranged so there will be no delay in finding what is wanted. In moving, not only is much time required for packing and unpacking, but much interesting material must be left behind, some things are lost and others broken, the work of rearrangement, which at best will require weeks for a large collection may be interrupted for months or years for the lack of room and suitable cases, and when done, the owner may require a long time to become as familiar with the new arrangement as he was with the old.

After the teacher has been some years in the place and won the respect of many people, they no more think of ousting him because of petty faults than one who was born among them.

In many lines of research acquaintance with the region and with the people such as one cannot get in a single year greatly facilitates one's work. Numerous illustrations of this might be given, did time permit. But the most serious objection to frequent moving is that lines of investigation pertaining to the locality require years in order that the work may be done with such thoroughness as to make it of permanent value.

The teacher of natural science who would imbue his pupils with the spirit of investigation should not be content to invoke their assistance in prosecuting his own researches. He should inspire them with a love of nature. To do this he must take them into the country. Some teachers whose early life was spent in the country or in a village fail to realize when they begin to teach in a city how meagre is their pupil's experience with the subjects they are trying to teach them. Until I take them into the country, some of my pupils have never seen a sheep, a peacock or a snake. Some imagine that strawberries grow on tall bushes. Many of them have scarcely, if ever, in their lives seen a hill or a river, save sometime, perhaps, from a car window. The expressions, "up stream" and "down stream" are meaningless to them. They listen attentively in the class-room to a description of the characteristics of a lake beach, but when shown a mole hill they are not sure that it is not a lake beach. Nor have they more knowledge of a beech tree. Not one in ten ever saw beech trees until taken to them by their teacher. The same is true of the hemlock, the witch hazel and many other interesting plants. Other trees, such as the button-

wood and ash they have seen but never had an opportunity to learn to know them. They do not recognize the note of the meadowlark or the kildeer, or know the difference between a chipping sparrow and a chipmunk.

The burrow of the woodchuck, the chimney of the crayfish, the ants caring for their pupæ and for the plant lice, the protective resemblance to their surroundings of the rabbit, or the grasshopper and whip-poor-will, the protracted flight of the swallow and the quick movements of the kingbird, the singing of the bobolink and brown thrasher;—these things cannot be brought to the school-room. Yet these, and not dried specimens, represent life. To fail to give them any knowledge of these things is to deprive them of a source of enjoyment whose pursuit would do more to enrich their lives than any luxuries that money can buy.

In the discussion following, two of the University men held that it was difficult to find problems on which high school teachers could work, and that they did not usually have the time, though it was held that some sort of original work was almost essential for the best kind of teaching. Yet the principal speaker on this topic, a high school teacher, had done very creditable science work, presenting at the opening of his paper an unfinished piece of work, which was original, to say the least.

Another member, however, presented a more encouraging view of this unpromising situation. He said what holds teachers back from attempting original work is the idea that they must do something great or nothing at all; but little things add to science. There are scientists in the state who wish to enlist teachers in small problems on distribution. Very simple things can be done along this line which in their broader meaning may be very complex. The mere collection of material, when the locality is known, is of importance.

The Description of a New Biological Laboratory

SAMUEL O. MAST, PROFESSOR OF BIOLOGY, HOPE COLLEGE, HOLLAND, MICH.

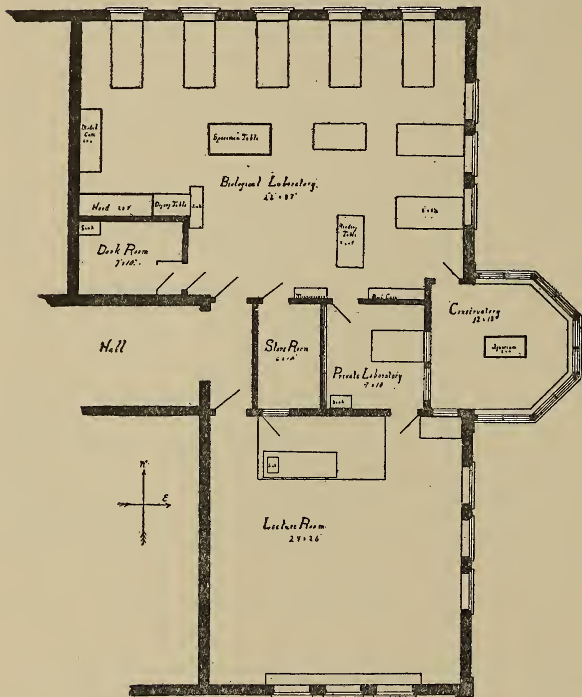
The plans here presented were drafted for a biological laboratory in process of construction at Hope College, Holland, Mich.

The laboratory will occupy the entire east end of the second floor, and in order to avoid direct sunlight as much as possible, will face the north. It is to accommodate 28 students, four at each of the seven working tables. These tables will be supplied with four drawers on either side. The drawers will be arranged one above the other in the middle of the tables. Adjustable swivel chairs with backs will be used at the tables.

There is a conservatory for plants, with glass roof and sides, and a cement floor connected with the sewer system by a drain. The dark room is to be used both for performing physiological experiments in the absence of light and for work in photography. The store room will accommodate not only biological material, but also chemical glassware, stains, etc. A hood which will accommodate three students at one time is supplied with water and gas. The lecture room will seat forty. It is adapted for demonstrations as well as quizzes and lectures, being in close connection with the store room, the private and the general laboratories.

We have planned a private laboratory, 9x12 feet—rather small, but better than none. As it is lighted only through the conservatory, it is

supplied with both gas and electricity. Every instructor should do some special work. This does not necessarily mean that every instructor should be an original investigator; he should be a teacher first of all. The special work he does may be the preparation of material in new ways for student use, or the working over of old experiments. Such a room, where the instructor may work undisturbed by the thoughtlessness of students, will also give them a wholesome notion of the difference between private and public laboratory belongings.



In discussing this paper, *Miss Edith Pettee, of the Eastern High School, Detroit*, gave a description of their NEW BIOLOGICAL LABORATORY, and some of the principal features are here given as it presents the high school side of the same question:

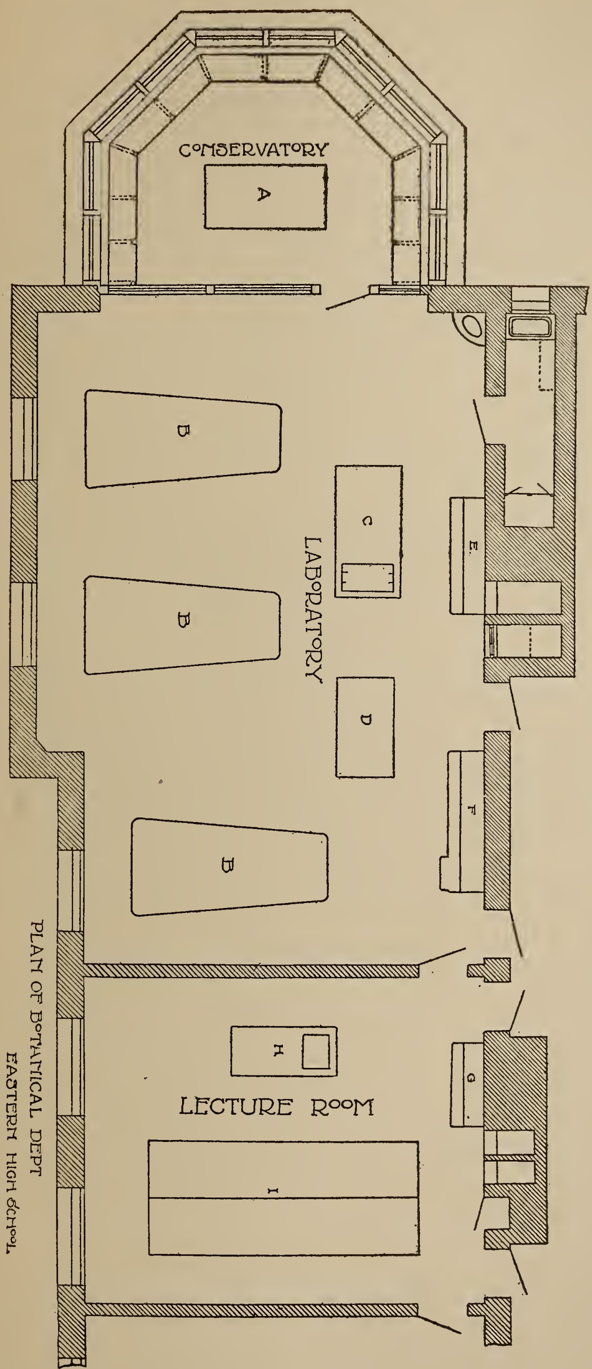
The laboratory faces the north and has three double windows on that side. Before each of these is a large flat iron shaped table, seating eight pupils, with drawer accommodations for four sections. The large table is convenient for beginning classes when materials are used in common while the sloping sides give better light to those away from the window. This light is not as good for compound microscope work as could be gotten at smaller tables before a greater number of windows.

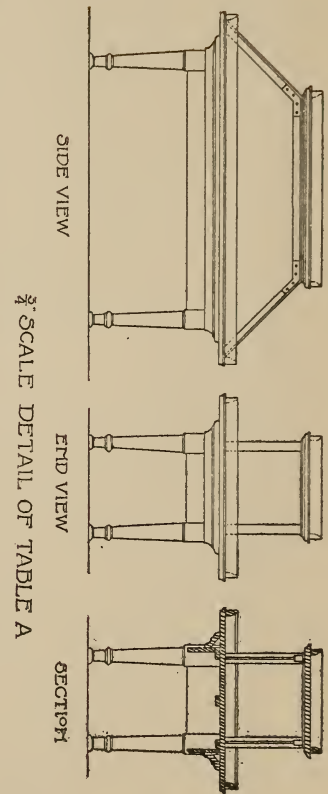
At C is a slate topped table with water and gas and a sink at one end. D is a teacher's table. Both these tables have drawers and cupboards underneath. There are also two cases for apparatus and materials.

At the side of the laboratory is a small store room which has cupboards, a sink, and a zinc lined wooden box to hold earth. This can be rolled into the conservatory and is a great convenience in potting plants. In this closet is also a gas hot water heater which is connected with all the sinks, a hand basin in the corner of the laboratory, and the conservatory. Turning on the water turns on the lighted gas which heats the water as it runs through the pipes.

A plate glass partition separates the laboratory from the conservatory which has double windows for sides and a double ground glass roof. The cement floor slopes toward a drain pipe in the center.

The metal covered, asbestos lined plant benches are around the sides with steam pipes underneath. It would be better to have the pipes on the





These cuts are reduced to one-third size of drawing.

floor as the benches get too hot for the plants. There should be a thermostat connected with the steam pipes. A double-decked aquarium table stands in the center of the conservatory.

The recitation room (lecture room) has a raised platform at I allowing three tiers of seats. There is a long demonstration table, H, which has water and gas and a covered sink at one end. There is a small closet and a case for specimens, G.

In a short talk on "METHODS BY WHICH NEW VARIETIES OF CULTIVATED PLANTS ARE ORIGINATED," *Professor C. F. Wheeler, of the Michigan Agricultural College* gave many ways in which the horticulturist produces such interesting results. Some new products were mentioned,—a daisy, four inches across, will soon be common property. In illustration of the ability of plants to vary with their surroundings it was said that the "dented corn" of the South may be changed to the "flint corn" of the North after three years planting in the latter latitude. In the discussion that followed Professor Davis called attention to the fact that the garden radish, the cabbage, and the cauliflower were the result of selection acting on the plants of the mustard family that had, respectively, somewhat thickened roots, or leaves, or flower-stalks.

Mr. J. W. Matthews, of the Western High School, Detroit, then spoke on "THE KIND OF ZOÖLOGY FOR HIGH SCHOOL WORK," saying in substance: The discussion of the subject of zoölogy in the high school should answer three questions: Why study zoölogy in the high school? When shall it come in the course of study? What shall be the branch of zoölogy presented?

There is no study in the curriculum that can produce better development of the powers of observation, comparison, and classification. No other subject gives such natural material for the development of observation, which is the first step in all study, and comparison, which establishes the facts thus gained, and classification, the logical conclusion. Pupils readily feel at this age the philosophy of the general laws of life, and need the breadth given to thought by considering human life in connection with animal life.

The best time for zoölogy is the second year of the high school course, following a year of botany, which shall have consisted of the study of plants as a whole, their habitats, when they flower, their method of flowering, their uses, etc. In fact much work in "God's laboratory" rather than confinement within the walls of a building with expensive apparatus and a few plants. A high school following such a plan for five years sent out six students who specialized in biology and were chosen assistants in the University of Michigan; four others, who went from college to teach biology in the public schools, or to follow lines of nature work; thus making ten pupils in that period of time inspired to choose life work in biology.

The conference closed with a lecture on "THE GERMICIDAL ACTION OF METALS AND SUNLIGHT," by *Dr. F. G. Novy, of the University of Michigan.* On account of his researches along this line much interest was taken in what was said, an abstract of which is here presented:

The surface or contact action of metals has been studied by chemists for many years. It is well known that certain metals as platinum and especially palladium absorb relatively enormous volumes of hydrogen. The gas is held in combination with the metal and is easily given off in a dissociated or active condition. As a result palladium-hydrogen is capable of exerting

a marked oxidizing action. It may convert, as Hoppe-Seyler pointed out, benzol into phenol, aldehydes into acids, liberate iodine from potassium iodide, etc. Moreover, hydrogen peroxide is formed when it is brought into contact with water.

The contact action of platinum is especially seen in the manufacture of fuming sulphuric acid by the new method. When platinized asbestos at a high temperature is brought into contact with oxygen and sulphur dioxide the metal acts as an oxygen carrier and the result is the formation of sulphur trioxide or sulphuric acid. By this procedure it is possible to prepare pure fuming sulphuric acid and it is more than likely that the "lead chamber" method of manufacture will be entirely done away with.

In 1889 Dr. Miller, the well-known American dentist of Berlin, showed that certain metals such as gold and copper exerted a marked germicidal action when brought into contact with bacteria. He explained this action as probably due to oxygen condensation on the surface of the metal. Behring, the discoverer of dipththeria antitoxine, repeated and confirmed Miller's experiments but the explanation which he offered was very different. He held that the bacteria, by means of their soluble chemical products, dissolved traces of the metals and that thus the germicidal action was brought about. In their studies upon the formation of organic peroxides, Drs. Freer and Novy showed that these substances are readily formed when some metal or even fabric was introduced into the mixture of the ingredients. In other words the surface or contact action of metals was manifested in much the same way as in the manufacture of sulphuric acid by means of contact with platinum. The view was expressed that probably the germicidal action of metals was due, not so much to the solution of the metal employed, as to the formation of peroxides by surface action.

It is well-known that sunlight is destructive to bacteria and the only explanation from a chemical standpoint which has been heretofore brought forward is that hydrogen peroxide is formed under the influence of the sun's rays. There can be very little doubt about the formation of this substance under those conditions, but the amount that is present is hardly sufficient to account for the rapid and intense germicidal action observed. The ultra violet rays are especially active in this regard. The explanation of the action of the sun's rays must be due either to the formation of powerful organic peroxides, such as those described by Drs. Freer and Novy, or to ionization. Investigations along these lines are now being carried on in the Hygienic Laboratory of the University.

PHYSICS SECTION

The Speaking Arc and Wireless Telephony

BY K. E. GUTHE, UNIVERSITY OF MICHIGAN

Ever since the invention of the electromagnetic telephone scientists have tried to reproduce sounds by means of instruments based on an action of the electric current other than magnetic.

Sir W. Preece of England made the first, and, to a certain degree, successful, attempt in this direction by constructing the so-called thermo-

telephone (Proc. Roy. Soc. Apr. 28, 1880). He made use of the alternating heating and cooling of an electrical conductor when a current of varying intensity passes through it. A fine wire subjected to a relatively strong tension is fastened at one end to a membrane. As an electric current is sent through the wire the tension will decrease, while on cooling it returns to its original value.

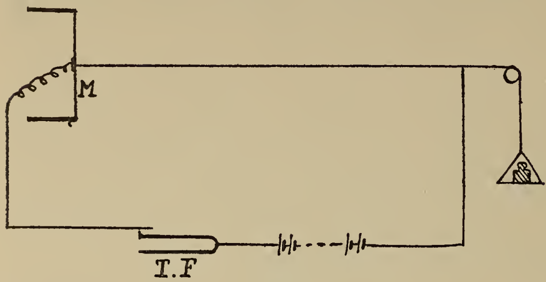


FIG. 1

By these variations in the tension the membrane is set into vibration and produces a sound.

All depends, then, on the ability of the temperature changes to keep step with the variations of the current, which may be produced in the ordinary way by a microphone. The wire of the thermo-telephone must, of course, be very thin to fulfill the above condition. Preece used a platinum wire 0.0076 centimeter in diameter, and finds that "the articulation, though muffled, was clear, and words could easily be heard." You see a similar instrument here [indicating]. The instrument exhibited is diagrammatically shown in Fig. 1. A phospor-bronze wire 90 centimeters long and 0.02 centimeter in diameter is subjected to a tension of about 200 grams. The membrane (M) is a bladder, which I put freshly on the frame about a week ago. The wire forms part of a circuit leading into one of the further rooms of the laboratory, far enough away to exclude all possibility of our hearing the source of sound directly. In that room a tuning fork is set up, which, as it vibrates, makes and breaks the current. As soon as I turn the switch so as to connect the wire with the circuit, all of you can hear distinctly the sound corresponding to the pitch of the tuning-fork.

Certainly an instrument like this can never vie with an ordinary telephone receiver as far as transmission of speech is concerned, and, indeed, for just about twenty years the electromagnetic telephone reigned supreme and without fear of competition.

The conditions have changed somewhat since the "speaking arc" was discovered. Here, as in so many cases, we owe most of our knowledge to the scientific and thorough following up of an accidental observation. In the fall of 1897 Dr. Simon observed while working with an arc light in the physical laboratory of the University of Erlangen, that it produced buzzing sounds similar to those caused by the making and breaking of a primary circuit of an induction coil in an adjoining room. Investigation showed that the two circuits ran parallel to each other for about 15 meters, and that thus currents induced by the working of the induction coil were superposed upon the steady arc-light current. The variations in the current

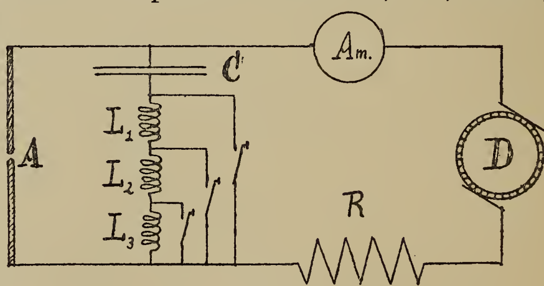


FIG. 2

through the arc gave rise to variations in the density and volume of the incandescent vapor column, and these to sound vibrations in the surrounding air. (Described in Wied. Ann. d. Phys., 64, p. 233, 1898.)

From this observation it was not such a wide step to a reproduction of human speech by the arc light. It was only necessary to superpose the varying currents of a microphone circuit upon the arc-light circuit. The experiments undertaken with this in view have proved, within the last year, remarkably successful.

But, before exhibiting the properties of the speaking arc, or, more strictly, the speech-reproducing arc, let us first consider the arc itself, without any reference to the impressions it gets from the outside. Curiously enough, all these years that scientists were looking for a sound-producing effect of the electric current, the arc has been humming and hissing into their ears without their understanding the meaning of it.

It was Duddell who first found out that the arc was a musical body, and that it was only necessary to give it proper opportunities to have it sing any tune desired. Duddell read in December, 1900, before the English Institution of Electrical Engineers, a very interesting paper on rapid variations in the current through the direct-current arc. That part of his work which is closely connected with our subject deals with the production of clear whistling sounds by the arc itself, when put in parallel with a capacity and an inductive coil whose coefficient of self-inductance may be L. Such a circuit forms an electrical resonator, whose vibration number n is given by the equation

$$n = \frac{1}{2\pi\sqrt{LC}}$$

The resistance, if very small, may be neglected.

All we need, then, is to set this resonator into vibration. It is not necessary to produce in the current variations of the same frequency, but simply to give it many and repeated impulses, just as a tuning-fork is set into vibration by being bowed. These impulses we can easily obtain if we make the arc very short—about one millimeter in length. The burning is then rather irregular, and carbon particles are liable to short-circuit the electrodes frequently, thus continually producing changes in the current. Under such conditions the arc will sing.

The apparatus is shown in Fig. 2. (A) represents the arc, (C) the condenser, (D) the source of current, and (R) the resistance. I have arranged a number of keys in such a way as to cut out different sections of the self-induction, (L_1), (L_2), (L_3), or the whole of it. According to which key I press down, you will hear sounds of a different pitch, all rather high, but distinctly of a musical and not unpleasing nature except when I short-circuit the self-inductance. Then the sound becomes too shrill to be called pleasant; its frequency lies somewhere between 10,000 and 12,000.. If the key connecting the arc with

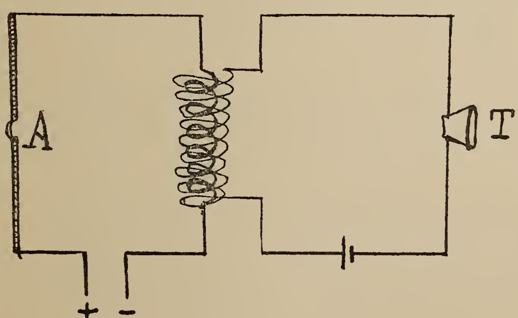


FIG. 3

the resonator circuit is opened the sound stops instantly; on the other hand, notice that no whistling can be produced when the arc is longer and the light steady.

A point of the greatest interest is that we have here the means of producing, by a constant-current dynamo, rapidly alternating currents in the branch containing the condenser and self-inductance, while in the arc we have a pulsating current.

Duddell stated that the hysteresis of an iron core in the inductive coil will instantly stop the tone. I have not found that to be the case. Even with an iron core, the singing can be produced without much trouble, though, I admit, not as easily as without the core. Further, the sound is more liable to vary in pitch, so that for the singing of a regular tune the iron core should be omitted.

Using a self-inductance with an iron core, made up of a large bundle of thin iron-wire, in series with the capacity, we can make the arc sing. The alternating current produces now a very rapid change in the number of lines of magnetic force. Thus, we can reproduce the famous Elihu Thomson experiments, of which I shall give only two.

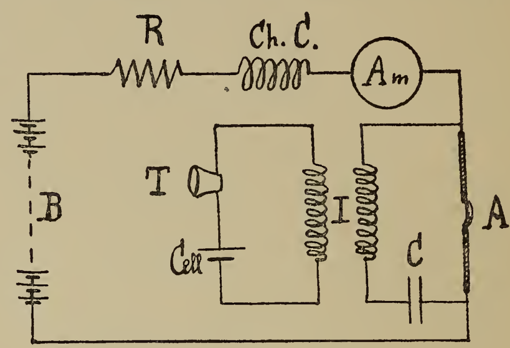


FIG 4

If we bring a closed wire near this magnetic field varying at a very rapid rate, currents will be set up in it by electromagnetic induction. On putting such a wire, consisting of several parallel coils and connected to the terminals of an incandescent lamp, on the iron core, the lamp glows. By rapidly slipping this metal ring over the inductance we decrease the self-inductance, and the tone of the arc becomes higher. As soon as the whistling of the arc stops, or as soon as the self-inductance is short-circuited, all these phenomena disappear.

Now let us return to the "speaking arc." The variations in the volume of the incandescent-vapor column are mainly due to the changes in temperature produced by the variations in the current. Suppose that the Joule effect is the same for the arc as for a metallic conductor; then the heat produced in unit time would be given by the formula

$$H = i^2r,$$

$$\text{and } dH = 2ir\, di.$$

Though this supposition is not exactly correct, experiments carry out the conclusion that the sound effect will be the larger with (1) the larger the variation of the current, and (2) the larger the current through the arc itself.

The number of arrangements proposed by different observers for the best working of the experiment under consideration is quite large. In Simon's original arrangement (Fig. 3) the transmitter (T) was put in series with a cell and one coil of a transformer, while the other coil was in series with the arc. Duddell, (Fig. 4) makes use of a choking coil (Ch.C.), to prevent the variations of the current from passing through the dynamo, and puts the transformer coil (I) and a capacity (C) in parallel with the arc.

I have found, however, that we can produce very satisfactory and strong effects by the simple arrangement shown in Fig. 5.

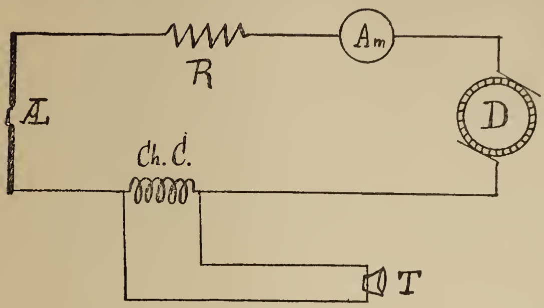


FIG. 5

The arc is produced by a continuous current of 12 amperes between carbons saturated with $NaNO_3$. By doing this we can easily obtain an arc five centimeters long. In series with the arc is a choking coil (Ch. C.), formed by a coil of a large electromagnet ($L=0.007$ h). No capacity is needed in the circuit, and the current is adjusted by ordinary rheostats (R).

The circuit leading to the room where the transmitter (T) is set up is connected to the terminals of the choking coil. The current through the transmitter (Mix and Genest) is about 0.5 ampere. This arrangement is extremely simple, but entirely sufficient to reproduce speech and other sounds with perfect distinctness.

[The experiments consisted in the reproduction of ordinary conversation, various songs, whistling, and violin playing, all being heard distinctly by everyone in the large lecture room, seating one hundred and sixty people.]

Of course, the breaking of the arc stops the sounds, but I observed that for a very short time after the breaking the sound continues, though rapidly decreasing in intensity, showing that the heated gases continue to conduct for a short time. This seems to have escaped other experimenters.

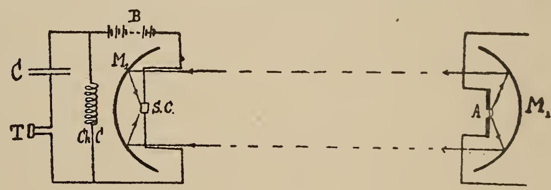


FIG. 6

The arc light then acts as an efficient telephone receiver. Attempts have also been made to use it as a transmitter. Any disturbance of the arc produced by impinging sound waves will change the resistance and consequently the current in the arc-light circuit, which may then be heard in a receiving instrument connected in parallel with the circuit. The results have not been very satisfactory, as the sounds heard are not very loud, and, besides, are mixed up with disturbing sounds, due to the irregularities in the arc light itself.

Since we live now under the sign of wireless telegraphy, it may be of interest that wireless telephony is made possible by the invention of the speech-repeating arc. We may simply make use of Bell's well-known scheme of throwing a beam of light upon a concave spherical surface at whose focus there is a selenium cell. Any change in the intensity of the light will be accompanied by a variation of the resistance of the selenium cell. The whole arrangement is shown in Fig. 6. We have the speaking arc (A) at the focus of one mirror (M_1). The light and heat variations are sent out to the receiving mirror (M_2), with its sensitive cell (SC). This cell is connected in a circuit containing a telephone receiver (T), which responds to any variation of the current due to the change in resistance of

the circuit. The telephone receiver will thus enable us to hear what has been spoken into the transmitter of a distant arc-light circuit.

It is hardly wise to speak of a great commercial value of the speaking arc light or wireless telephony. Nevertheless, we can think of cases where they may be of practical value, but, even without that prospect, the musical and speech-reproducing arcs belong to the most interesting discoveries of the last few years.

NOTE:—A paper, treating a portion of the above subject more in detail, has appeared in the October number of *School Science*, vol. 2, p. 209-215, 1902.

Pupin's Invention

PROFESSOR G. W. PATTERSON, JR., UNIVERSITY OF MICHIGAN

Much interest has been shown by the scientific world in Professor Pupin's invention of the loaded telephone line, an invention which has vastly improved the transmission of speech over long distances. I may, briefly, recall the conditions present in the telephone circuit. The line has, sent into it, a certain periodically varying current, called a complex harmonic current. Very little of this current reaches the receiving apparatus at the distant end, in general less than one per cent. on long lines; the rest is abstracted by the charging of the line and held back by the line's resistance. If this resistance were absent, the charge waves would be transmitted without loss. So the electrostatic capacity of the circuit, in conjunction with the resistance, is an objectionable feature. If it were possible to suppress one or the other, long distance telephony would be possible to any distance. As it appears to be out of the question to suppress either, some counter effect must be sought. Now, it is well known that self-inductance combats capacity, and so increased inductance is the most evident remedy. But how to apply it was the puzzle. It was early suggested by some to put self-inductance in parallel with the capacity, but without good effect; others have tried large inductances in series, which also resulted in failure to produce the desired effect. The theoretical problem was so complex that no one before Pupin had solved it. Consequently, their experiments did not take the proper form. Professor Pupin first settled the theoretical problem, and followed with experiments performed under favorable conditions.

Pupin introduced into the line wire many small equal and equally spaced inductances. The introduction of more self-inductance demands more energy on the line to transmit the same current; but this is no detriment, as the increase of energy hinders the attenuation of the current from wave to wave along the line, Mathematically, a telephone line is like a vibrating cord, and although reasoning by analogy is exceedingly dangerous, yet it may be very helpful when the mathematical parallelism is close, provided it is checked by experiment. Pupin illustrates the telephone problem by means of the vibrating string. Suppose a very long, light, elastic string, which has no stiffness, to vibrate under the influence of simple harmonic impulses communicated to one end. If the string is long, waves will be produced which, because of air and other friction, have smaller and smaller amplitudes as they run along the cord from the source. With short

strings the phenomenon of stationary waves is produced, but in the case considered they are not present to any considerable extent. Had the string more mass in the same cross section, the damping of the waves would be less. Suppose, as a substitute for more uniformly distributed mass, we load the string at frequent intervals by means of many equal and equally spaced masses, we may approximate the uniformly loaded string. If, however, we apply the whole load at one point, or divide it among a few points, we will defeat our object, as the large mass will have a tendency to anchor the string and to reflect the waves and not to transmit them. Thus we may explain the failure of large inductances to improve telephony, when the inductances are located at a few points. Calling a whole wave length 2 Π, if the loads are at intervals A, so small that sin $\frac{A}{2}$ differs little from $\frac{A}{2}$ (say less than 2 per cent.), when the wave is well transmitted.

In the telephone circuit we deal with complex harmonic waves which consist of a combination of simple harmonic waves, each of the form

$$i = I\, e^{-bx} \operatorname{Cos} (pt - Bx)$$

in which i is the current at the distance x from the transmitter at the time t, and I is the maximum current at the origin.

The constants b, p and B have to do with the form and velocity of propagation of the wave; the constant b is the attenuation constant and has for its value

$$b = \sqrt{\frac{pC}{2}\left(\sqrt{p^2L^2 + R^2} + pL\right)},$$

in the case of uniformly distributed resistance (R), capacity (C) and inductance (L). If L is small in comparison with R this reduces to

$$b = \sqrt{\frac{pCR}{2}} \text{ (nearly)};$$

and if L is large in comparison with R

$$b = \frac{R}{2}\sqrt{\frac{C}{L}} \text{ (nearly)}.$$

In the former case higher frequency (larger values of p) causes more attenuation; in the latter case the attenuation is independent of the frequency within the limits of the approximation, and large values of L cause reduced attenuation. Both of these properties are favorably to good telephony; for small attenuation means loudness, and uniform attenuation for all frequencies means faithful reproduction of the quality of the voice.

To illustrate the application of the invention, we may take a line 250 miles long without the loading coils, suppose L=o, R=9 ohms, C=O. 074 m. f. per mile, b=0.000004.

This small value of b (0.000004) would make it impossible to hear anything over the line. If to this line we add loading coils having a resistance of 9 ohms extra per mile (in all R=18 ohms) and an inductance of 0.056 henry per mile, we obtain b=0.025, in which case speech will be good.

I understand that the Bell Telephone Co. (Am. Tel. & Tel. Co.), to whom Professor Pupin has sold his invention for a princely sum, is now experimenting on a line 6000 miles long, obtained by using in series three New York-Chicago lines, which is equivalent to a metallic circuit between cities 3000 miles apart. The line is said to talk well, and it appears quite

probable that there will be no difficulty in using a line from New York to the Pacific coast. One big advantage from the commercial standpoint is due to the fact that a New York-Chicago line, which now costs $250,000 for copper alone, may be built with loading coils for less than half that amount. If the saving of capital is as great as expected, the price paid Professor Pupin will prove quite moderate.

Carman Opaque Projector

The "Art of Projecting" has a long history, and has developed many forms of apparatus. The "magic lantern" type and its modifications have become so familiar, and is in such common use, however, that it is unnecessary to discuss it. Projection by reflection is far less common; in fact, its possibilities are generally unknown.

Many years ago, attempts at projection by reflection were made in a small way, which resulted in such apparatus as the "Wonder Camera," "Megascope," "Aphengescope," etc. It is probable Chadburn was the first to design an instrument for making projections by reflection, and for a time it was known by his name.

All the earlier forms of instruments, however, attempted only the projection of small pictures of small area on the screen, and with but feeble illumination. Recently a German firm has developed a projector known as the "Epidiascope," a machine weighing many hundreds of pounds and costing many hundreds of dollars. It is highty organized, contains many mirrors, and gives satisfactory results only under the most favorable conditions, and then but for a short period of time. Extensive repairs are frequently necessary.

The Carman Opaque Projector, which is on exhibition before you to-day, is of less weight, is manufactured at a less cost, and is more durable than is any apparatus attempting to do what it actually accomplishes. It is believed to be the only single piece of apparatus that accomplishes the following results, passing from one form to another, without a moment's delay:—

1. The projection of opaque pictures in their true colors.
2. The projection of diagrams from sheets or books.
3. The projection of reading matter or music, from the sheet or printed page.
4. The projection of opaque objects either in a vertical or horizontal position.
5. The projection of all botanical subjects from life, in colors.
6. The projection of apparatus and small machines in operation.
7. The projection of microscopic slides.
8. The projection of micro-photographic slides.
9. The projection of stereopticon slides.
10. The projection of animated life by the use of the moving picture attachment.

The apparatus, as designed, eliminates all mirrors, unless the reversing effect is desired. This effect may be produced either by means of a mirror or a prism.

The features of the Carman Opaque Projector, to which especial attention is called, are· The objective lens, especially designed and built for the

apparatus; the automatic, 90° high candle-power electric lamps used for illumination purposes; the mechanical features making it possible to project stereopticon slides, microscopic slides, and opaque pictures and objects during the same lecture or demonstration.

The Projector which is in operation before you, has been purchased by the University of Michigan for use in the Medical Department, and others are soon to be placed in other universities and colleges.

You are cordially invited to make a close inspection of the apparatus now on exhibition, which inspection will convey to you far more definite ideas than can be given by an oral description.

The Nernst Lamp

SYNOPSIS OF PAPER

The Nernst lamp was originally designed and patented by Dr. Nernst› of the University of Göttengen.

Later the lamp was brought to America by Mr. George Westinghouse, and further developed and patented by his employees, Mr. Wurts, Mr. Potter, Mr. Hanks and others.

The lamp is composed of five principal parts, as follows: The "glower," "ballast," holder, "heater-porcelain" and heater-case.

The glower is the part of the lamp that corresponds most nearly to the filament in the usual form of incandescent lamp. The difference between the filament and the glower is that the glower is made of a mixture of rare earths and a binding material, which are baked together into a slender tube of porcelain. The average tube is about 25 millimetres long anu .63 of a millimetre in diameter.

A peculiar feature of the glower is that it is practically a non-conductor when cold, but becomes a conductor of the electric current when sufficiently heated. The glower is not contained in a vacuum bulb, but gives its brilliant white light exposed to the atmosphere. Under these conditions, the life of the glower is, on an average, greater than the life of the highest grade of incandescent lamp fitament.

The ballast is a steadying resistance introduced in series with the glower, for the purpose of regulating the current flow, and in consequence increasing the uniformity of light intensity and increasing the life of the glower. The form of ballast is unique in design, and involves many interesting principles. A full explanation would require more space than is allotted to me.

The heater is composed of platinum wire placed in a small tube of ordinary porcelain, which is placed directly above the glowers, By means of an automatic switch, the current is changed from the heater to the glower as soon as the glower becomes a conductor.

A heater case or glass globe is placed over the glower, in order to raise the temperature of the air in which the glower operates.

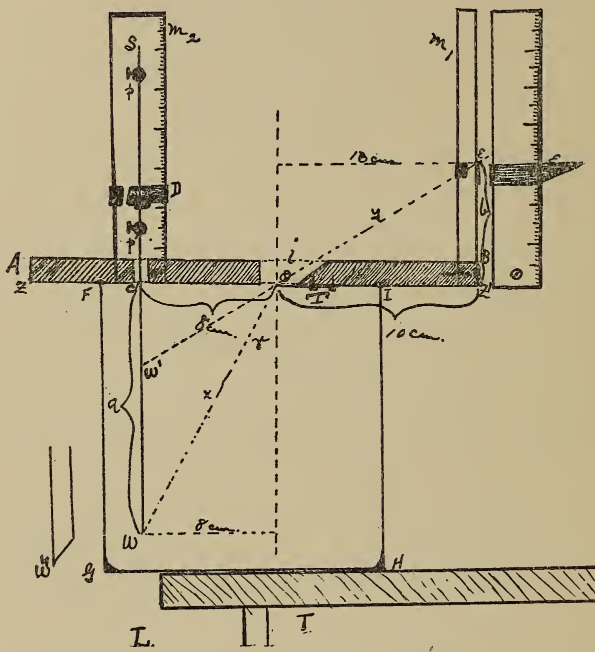
The lamps are made with one, two, three, six and thirty glowers. The efficiency of the six-glower lamp approaches that of the enclosed arc lamp. Tests seem to indicate that the single-glower lamp is at least twenty per cent. more efficient than the best vacuum incandescent lamps.

(Ed.—A single glower and six-glower lamp were shown in operation by the speaker.)

The Index of Refraction of Water

CHAS. H. SLATER, PONTIAC, MICH.

The device herewith presented is developed largely from a similar one called an Indexometer, described in *School Science* last May. The method there suggested did not require a dark room nor a bright source of light and so was well adapted to our needs. The per cent of error seems rather large. Our students have used this apparatus in the laboratory with ordinary light and the per cent of error is less than one-half of one per cent.



Index of Refraction = u. i=angle of incidence; [1]R=angle of refraction

$$u = \frac{\text{Sin } i}{\text{Sin } r} \qquad \text{Sin } i = \frac{10}{y}; \ \sin r = \frac{8}{x}$$

$$x = \sqrt{a^2 + 8^2} \qquad y = \sqrt{b^2 + 10^2}$$

$$\therefore u = \frac{\text{Sin } i}{\text{Sin } r} = \frac{\frac{10}{y}}{\frac{8}{x}} = \frac{10\,x}{8\,y} = \frac{10\sqrt{a^2 + 8^2}}{8\sqrt{f^2 + 10^2}}$$

The construction and method of use is as follows: A rectangular glass jar, F G H I 6.5 cm. by 14 cm. and 18.5 cm. high is filled with the liquid whose index of refraction is desired. Upon the jar, and grooved to closely fit it, is placed a paraffined cover of hardwood, 10 cm. by 20 cm. and 2 cm. thick. This is provided with two openings, and two metric scales, each about 30 cm. long, mortised and glued into the wood at right angles to it as shown in the diagram. A small opening, C, is placed near one end to allow the free movement of the rod S-W (a coarse wire will do) which is fastened to the scale M_2 by means of two binding posts, p and p,[1] so placed

that at all times it will be normal to the under surface of the cover, A B. The scale is provided with a strip of brass, D, bent to clamp the scale and to extend behind and in front of the rod, thereby avoiding parallax. A mark for an index is filed on the rod. The central opening, 2.5 cm. diam., is bevelled back somewhat toward B. On the lower surface of the bevelled edge a piece of thin sheet iron, T, is fasted, so placed that its edge O is normal to the line Z^1O Z and is 10 cm. from Z^1 and 8 cm. from the farther side of the rod S-W. This piece of iron serves as a sight edge at the surface of the liquid. The scale M, is so placed that one edge shall just touch the line Z^1Z which passes through the center of the opening O, and should read from the lower surface of A-B. This scale is also provided with a brass sight edge, E, bent to clamp the scale and yet move easily along it. The rod, S-W is raised so that *W* is at *C*. This is done easily by placing A-B on a glass plate. While W is resting thereon the rod is clamped and a reading is made from the file mark on the rod. It is then lowered to any desired position, placed in position on the jar, and a second reading from the file mark is taken. The difference between these two readings gives the length *A*. If the point, W, be filed very oblique as at W^{11}, it appears much more distinct. In practice it is very important that the sight edge plate T be covered by a thin film of the liquid or the surface will be greatly distorted and consequently a large error introduced. We have found it advisable also to place the jar as indicated on the edge of the table, and to place a common gas jet below or near as at L, to illuminate the point W when adjusting E. A ray of light from W passes the sight edge O, and is bent downward so that W appears to be raised to W^1. The sight edge, E, is then adjusted so that W^1, O, and E seem to be collinear. The reading is then taken, and from this data, the index of refraction computed as shown in the formulæ and table of results. The apparatus is easily made and is inexpensive. The glass jar can be obtained from Eberbach & Son Ann Arbor.

DATA TAKEN FROM STUDENTS' WORK

Reading Z (point of rod, W, on Zero line) = 39.47 cm.

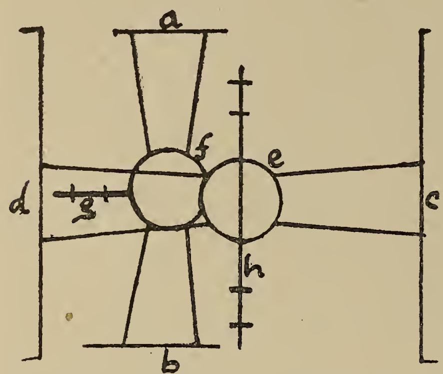
Name	Trial	Reading W, rod down	Z—W=A	B	X	Y	$u = \frac{\text{Sin } i}{\text{Sin } r}$
Mal.	1	24.45	15.02	12.50	17.01	16.00	1.328
G	2	25.44	14.03	11.40	16.14	15.06	1.317
M	3	26.54	12.95	10.35	15.22	14.36	1.324
G	4	28.30	11.17	8.20	13.72	12.93	1.326
M	5	29.00	10.47	7.20	13.17	12.32	1.335
G	6	24.40	15.07	12.60	17.06	16.08	1.327
M	7	25.60	13.87	11.40	16.01	15.16	1.328
G	8	25.00	14.47	11.70	16.53	15.39	1.342
M	9	26.65	12.82	10.10	15.11	14.21	1.329
G	10	27.20	12.27	9.50	14.64	13.79	1.327

Average value for u = 1.328
Correct value = . 1.332
Error = ...004
Per cent = . . . 3-10 %

A Device to Show Composition of Vibrations

H. D. MINCHIN, INSTRUCTOR IN PHYSICS, CENTRAL HIGH SCHOOL, DETROIT, MICH.

The apparatus consists of two small pocket mirrors, *e* and *f*. The mirror *e* is arranged to vibrate vertically by being suspended to two vertical posts, *c* and *d*, by rubber bands.



The mirror *f* is suspended to a vertical post, *a b*, by rubber bands, and vibrates horizontally. The rubber bands may be fastened to the mirrors by wires soldered to the backs.

The two mirrors are so arranged that a beam of light incident upon *e* is reflected to *f* and thence to a screen.

Wires *g* and *h* are fastened to the backs of the mirrors, as per figure. Weights may be placed on these wires, and thus the velocity of vibration may be regulated. The source of light may be a ray of light from a lamp passing through a pin hole in a card, a lantern, or the sun.

By regulating the velocity and a proper adjustment of the tension of the rubber bands, any desired figure may be obtained.

The Joliet Township High School Physical Laboratory

W. J. RISLEY

Referring to the accompanying plan we find that the Department of Physics occupies seven rooms: A recitation room, general laboratory, office and private laboratory, dynamo room, lecture room, dark room and work room. They constitute the entire south and central portions of the fourth floor of the middle section of the building, and contain an aggregate of about three thousand five hundred square feet.

The lecture room, general laboratory and recitation rooms have each telephonic connection through the superintendent's office with the remainder of the building, a dummy electric clock and a thermostat. These rooms have each a large 8′9″ by 3′0″ instructor's table, while the office and work rooms have each a 6′4″ by 3′0″ glass-top work table. Each table has an abundance of drawer space, a stationary pneumatic trough, with waste pipe and connections for hot and cold water, gas, steam, compressed air and electricity.

In the general laboratory are eight stationary students' tables, 6′0″ by 3′6″ and 3′0″ high, at each of which four pupils can work. These are fitted with individual gas cocks, cut-out boxes and cupboards, in which the pupils store their Bunsen burners, gas tubing, ring stand rods, rings and silk-covered cables for electrical connections. For ring stands, brass rods screw into nuts which are fixed in wooden blocks firmly attached to the under side of the table. An office stool, which can be placed under the

table is furnished each pupil, while at the ceiling above each table is a reflector for electric lights. A three-inch stone shelf extends along the entire south wall of the general laboratory and office, and along the east wall of the work room. Gauges for compressed air, gas, steam and water occupy convenient places on the walls, the last being immediately over a stationary marble-top washstand containing four basins. Eight windows, with an aggregate area of nearly two hundred square feet, supply an abundance of good light. These are fitted with ordinary curtains and with dark curtains, by means of which all light may be completely shut off.

The office has desk room for the head of the department and his assistant, a bank of drawers for apparatus, a library closet and a cloak closet.

The 34′0″ by 27′0″ lecture room, with a seating capacity of 100, has a large skylight just above the instructor's table, along the inner edge of which are six incandescent lamps. This skylight and the windows of the room have dark curtains, by means of which all light may be excluded. The seats are arranged in seven consecutive tiers, each 1′0″ higher than the tier in front of it. On an ample platform in the rear of the room is the projection lantern, the 10′0″ by 12′0″ curtain for which is hung above the blackboard just back of the instructor's table.

The dark room will be fitted with the appurtenances which usually accompany such a room, including a complete photographic outfit for taking, developing and printing photographs and slides.

In addition to the above-mentioned laboratory table, the work room will be equipped with a large general work bench, an electrically-propelled lathe for both wood and metal work, and the necessary apparatus for glass-blowing and repairing.

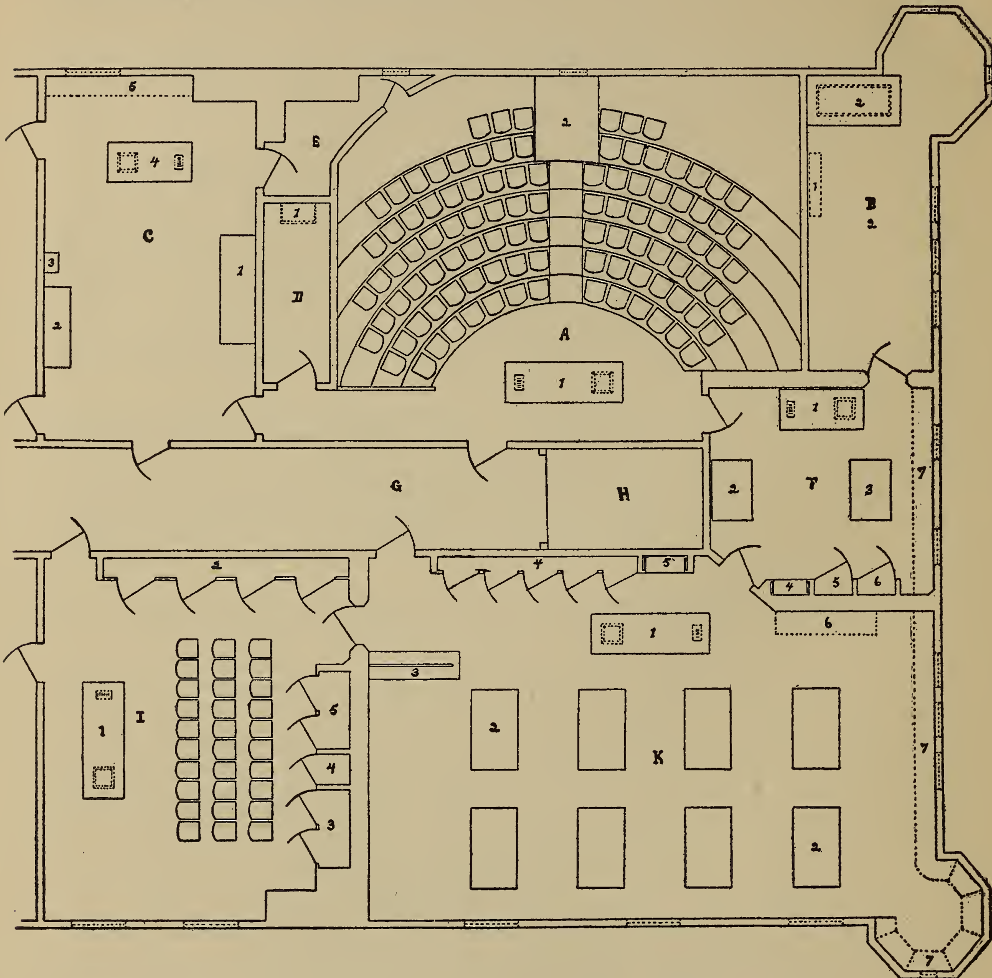
Beneath the raised portion of the lecture room is a large storage space for boxes, battery materials, etc.

Thirteen closets extend from the floor to the 13′0″ ceiling, and having an upper and a lower section, are built in the walls of the general laboratory and recitation room. These closets vary in depth from 1′0″ to 2′6″, and in width from 3′0″ to 4′6″. Their heavy doors close against weather stripping, thus rendering them as nearly dust-proof as practicable. Two banks of thirty-two drawers each are used for smaller pieces of apparatus that have been assembled for the various experiments. Thus it is seen that we have sufficient shelf room for our present and future needs.

In the dynamo room a 3 K. W. motor is operated by power from the city electric light plant. To this motor is directly connected a rotary converter, which can furnish a 3 to 25 volt or a 25 to 125 volt direct current, a single-phase alternating current up to 90 volts, a double-phase or a triple-phase alternating current. The controlling switch board, furnished with stationary ammeters, voltmeters and rheostats, contains also cut-outs for supplying these currents for experiments to be performed in the dynamo room. Concealed cables connect it with the marble distributing switchboard in the general laboratory. This switchboard so stands that it can be studied from either side, and the cables be exposed for testing purposes, etc.

Switches supply the instructor's tables in the botanical and physiographical laboratories and all stndent tables in the physical laboratories with high and low voltage direct, and with city and single phase alternating currents. In addition to these currents all instructor's tables in the physical and chemical laboratories are supplied with two and three-phase alternating currents. With the necessary rheostats for regulating purposes, that

portion of the recitation work requiring electricity is now carried on very satisfactorily with the currents from our own converter. In the not-too-distant future we expect to have our own electrical plant to supply the entire building with light and power.



A. Lecture Room—
1. Instructor's Table.
2. Platform for Projection Lantern.

B. Dynamo Room—
1. Switchboard for Converter.
2. Rotary Converter.

C. Work Shop—
1. Work Bench.
2. Lathe for wood and metal.
3. Motor.
4. Instructor's Table.
5. Stone Shelf.

D. Dark Room—
1. Sink.

E. Toilet Room.

F. Instructor's Private Office.
1. Instructor's Table.
2. } Desks.
3. }
4. Drawers for Apparatus.
5. Library.
6. Closet.
7. Stone Shelf.

G. Hall to Chemical and Botanical Laboratories

H. Stairway down to third floor.

I. Recitation Room—
1. Instructor's Table.
2. }
3. } Closets for apparatus.
5. }
4. Elevator.

K. Laboratory—
1. Instructor's Table.
2. Students' Tables.
3. Switchboard for Students' Tables.
4. Closet for Apparatus.
5. Drawers for Apparatus.
6. Washstand.
7. Stone shelf.

Discussion of the Physics Note Book Problem

CHAS. H. SLATER, PONTIAC, MICH.

WHAT? When our laboratory work begins, each student is required to provide himself with two note books, a temporary book for taking down the data, etc., while performing the experiments, and a permanent note book in which the data for each exercise is carefully recorded and discussed. The former consists of a small, *bound* book, while the latter is a larger, well bound book of squared paper of medium quality.

WHEN? As the work progresses in the laboratory, the student records all data and observations in the temporary note book. All work is verified by the instructor before another exercise is commenced. The permanent record is then made by the student at home, and is occasionally called in by the instructor for examination and correction. Inasmuch as we usually have but two or three days a week for recitation, the first four or five weeks in the fall are given to text-book work entirely. This, however, lessens the time for laboratory work, hence it seems best here not to require the permanent record to be made in the laboratory, but to devote all the time at our disposal there to the experimental work. Later, at home, the student writes up his permanent record. which is more carefully done and more fully discussed than could have resulted from an endeavor to finish all work in the laboratory.

HOW? After the first two experiments are completed by all, detailed directions are given the class regarding how to write up and discuss the exercises in making the permanent record. One of the best note books of the previous year is obtained and placed where the students may examine it while writing up their first two exercises. These are to be finished by a certain time and handed in. This work is very carefully examined and marked for correction, and a part of a recitation period is given up to a discussion before the class of the mistakes, corrections, etc., and further suggestions are given for the future work. The books are not called in again until about twelve more experiments are completed. As all results have been previously verified, the discussion of the data, errors, methods, etc., of the experiment receive the most of the attention this time. Each book is then returned with a slip of paper upon which the most important criticisms are noted. Each student is required to see the instructor relative to these corrections. Subsequent examinations of the books are made in a somewhat similar manner, but less time is now required, as the method work by this time is quite well understood and few corrections will now be necessary.

SUPERINTENDENT C. L. BEMIS, IONIA

We have no room devoted solely to laboratory purposes in physics. The apparatus is set up on what might be called a shelf extending the length of the room. Two days each week are given to experiments in physics, and from two to six pupils work at the same time; two only on one set of apparatus.

Each pupil takes notes on what he does in the laboratory, draws pictures of the apparatus, and writes out descriptions of it on loose sheets of paper. These are corrected, after which they are copied into a book so constructed that each leaf may be taken out. After the copying is done, the books are again looked over, and if there are any errors of importance

the leaf is removed and the work copied the second time. Small errors are corrected, but for these the leaf is not taken out. When all is correct, the book is checked and considered passed.

I find that the two most difficult results to secure, so far as the books are concerned, are accurate expression and intelligible drawings. Of the two, the written part seems to be the most difficult, and it is only after repeated re-writing that I secure satisfactory results.

Every student should fill out a laboratory note book.

DE FORREST ROSS, SCIENCE DEPARTMENT, YPSILANTI, MICH.

The laboratory note book is by no means the least of the many perplexing problems that confront the teacher of physics. The average student takes to it as kindly as the boy of old did to the Saturday afternoon "composition." Hence, to make it more attractive and useful to the student is sufficient reason for its place in the questions of a Physics Conference.

That the note book, then, may serve its mission in the highest degree, it would seem to me of first importance that the student be made to see that it has a value to him that he can ill afford to be without. One way to bring this about is to have our colleges and university place a good deal of value on the note book from the high school applicants for admission to these classes, and then for the high school teacher to see that the student understands this attitude of these institutions.

Having established, then, in the student's mind a real value to his note book, he will now take more pride in making it more what it should be—a true record of his efforts, and highly intelligible.

It only remains now to so arrange the order and details of the experiment and observations as to show, in a clear, concise way, that the student has a fairly clear idea of just what he is doing and what he is doing it for. When this is so stated that, without covering a quire or two of note paper, the author will not need to be present to make his work intelligible to one looking over his record, the note book will possess more than a disciplinary value.

H. M. RANDALL, UNIVERSITY OF MICHIGAN

What to require of pupils in the way of writing laboratory notes is a question which does not seem capable of a definite decision, for it depends largely upon the time at the disposal of the teacher. The time for correcting notes, which may be time well spent in larger schools where not so much is demanded of the teachers, is likely to be very poorly spent in smaller schools where teachers are apt to be overworked.

The classroom work, including experimental demonstrations, and the work of keeping the laboratory and its apparatus in order should be well done, as it is by these means that the most physics can be taught, and until the teacher has enough time at his disposal to do this, and some to spare, it is likely to be a poor policy to undertake the correction of rather elaborately written note books.

For several years my pupils were required to write, first in temporary note books and finally in permanent ones, a statement of the problem, the apparatus used, give a complete description of the methods employed, place the results and computations in tabular forms, discuss fully what the results indicated, and make drawings of the apparatus, where such drawings

would simplify the description of apparatus or the method used. The correction and recorrection of such notes required about two hours of my time every evening. and as the forenoons were filled with recitations and the afternoons with laboratory work, there was not left sufficient time to make satisfactory preparation for either. As a remedy, the pupils were expected simply to write the problem, the apparatus used, put results and computations in tabular form, and state very briefly what the results showed. By previously discussing the laboratory problems quite fully in class, and having the laboratory apparatus always in order, it was possible to spend most of the two-hour laboratory period in quizzing pupils about the work they were doing, and to look over the brief notes at the completion of each problem, so that no additional time was required. The time formerly given to correcting notes was largely given to preparation for class work, and, on the whole, the subject was better taught.

W. A. MORSE, WESTERN HIGH SCHOOL, DETROIT, MICH.

In the high school, at least one-third the time given to the subject of physics should be devoted to laboratory work. It is here that the pupil acquires the habit of careful observation and the power to draw his own inferences from the work performed. A carefully kept note book should be the record of the laboratory work. In order that more may be accomplished during the laboratory period, we require the pupils to keep two note books: one (a temporary book) in which all mathematical calculations and manipulations of apparatus are recorded; another in which the working notes are copied, together with a drawing of the apparatus used. This, we believe, gives better opportunity for rapid work in the laboratory, and inspires the pupil to neatness and accuracy in the use of good English in writing out his final notes.

For the permanent notes we use the flexible self-binder, into which the cross-section paper can easily be inserted. All data should be taken at the time of the experiment, and under no circumstances should it be changed until after corrections have been added by the instructor. Both books should be placed in the hands of the teacher for correction, in order that he may see that no after-changes have been made.

The system ot correction may be by check marks through the notes or by the use of numbers. We prefer the latter method, as it is less humiliating to the pupil and answers the same purpose.

H. D. MINCHIN, CENTRAL HIGH SCHOOL, DETROIT, MICH.

On the first day of the semester our classes meet for enrollment and assignment of lessons. We then request each pupil to provide himself with the following for laboratory work:

1. A laboratory manual.
2. A temporary note book.
3. A permanent note book.
4. A half dozen sheets cross-section paper.

The temporary note book is to be in size about 6 by 9 inches, containing about 130 pages, and a good quality of paper. The permanent note book is to be about 8 by 10 inches, well bound, good paper, and containing about 100 pages. We choose this size as it affords the required space for tabular forms, for data, without crowding.

On the second day of school the temporary note book and manual are to be brought to class, and we take about two-thirds of the recitation period to give directions for the drawing up of the tabular forms. These are to be drawn up in the temporary note book and handed in for correction. This is done outside of class, and thus the mechanical work is ready when laboratory work begins.

The temporary note book is to be used for all computing, and all observations and notes on the experiment are to be entered therein. This record is to show what the pupil actually observed and what he has to say of his observations.

As data are obtained we give methods of computing results, calling out by discussion what of the data calls for explanation and what results mean. Attention is called to limits of accuracy of data.

At the close of the period all results are checked, and pupils are then expected to replace all apparatus and leave desks in order.

We have tried two methods in discussing data.

1. The class method.
2. The individual method.

The latter is by far the more satisfactory, but requires considerable more of the teacher's time.

In writing up the experiment in the permanent note book, the following order is observed:

1. The first three pages are to be left for index.
2. Begin the writing of all experiments on the left-hand page. On the first line put experiment number and date; then the purpose is to be stated; following this a list of the apparatus with diagrams where necessary; the operations are then given. At the top of the right-hand page the tabular form is to be placed and the discussion follows.

In this discussion is brought out the meaning of the data, the steps in obtaining end sought and conclusion arrived at. The notes made in the temporary note book are used in this discussion.

Each experiment is discussed and written up immediately after it is performed.

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